RESTRICTED OP 1064

COMPUTER MARK I AND MODS.

DESCRIPTION AND OPERATION

A BUREAU OF ORDNANCE PUBLICATION 29 JUNE 1945

Change No. 1 made 3/18/54
Hamby, YNSN

RESTRICTED OP 1064

COMPUTER MARK I AND MODS

DESCRIPTION AND OPERATION

29 JUNE 1945

NAVY DEPARTMENT

BUREAU OF ORDNANCE

WASHINGTON 25, D. C.

RESTRICTED
ORDNANCE PAMPHLET 1064
COMPUTER MARK 1 AND MODS

29 JUNE 1945

1. Ordnance Pamphlet 1064 describes the theory and operation of the Computer Mark 1 and Mods. A companion publication, Ordnance Pamphlet 1064A which is now in preparation, will cover care and maintenance of these equipments.

2. This publication is to be used by: operating personnel, both during instruction and while on actual duty; personnel of installing activities; and inspectors and other officers of the Bureau of Ordnance.

3. This pamphlet supersedes NAVORD OD 4184 (Revision B) which should be destroyed.

4. The following NAVORD OD'S which will be superseded when Ordnance Pamphlet 1064A has been completed contain additional information on Computers Mark 1 and Mods:

NAVORD OD 4174 (Revision C)
NAVORD OD 3133 (Revision A)
NAVORD OD 3137
NAVORD OD 3139
NAVORD OD 3140 (Revision B)
NAVORD OD 3180
NAVORD OD 3181
NAVORD OD 3183
NAVORD OD 3184 (Revision A)
NAVORD OD 3185 (Preliminary)
NAVORD OD 4186
NAVORD OD 5157
ORDNANCE PAMPHLET 1453 (Preliminary)

5. This publication is RESTRICTED and should be handled in accordance with Article 76, U.S. Navy Regulations, 1920.

G. F. HUSSEY, JR.
Rear Admiral, U.S. Navy
Chief of the Bureau of Ordnance

Prepared For
THE BUREAU OF ORDNANCE
by the
FORD INSTRUMENT COMPANY, INC.
Long Island City, New York

QUICK REFERENCE INDEX

More detailed breakdown on next two pages.

This page is hot linked. Click the page/subject you want. The file is also searchable. Enter the phrase you want in search block. If that does not work, try a different phrase OCR isn't perfect.

If link does not work, the page you want is in a different file. Return to original page to download.

CONTENTS

There is a detailed ALPHABETICAL INDEX on page 421

There are schematic diagrams of the entire Computer Mark 1 at the end of this pamphlet

INTRODUCTION

Ordnance Pamphlet 1064 describes the Computer Mark 1 and tells how to operate it. All maintenance information is covered in a continuation of this pamphlet which is bound separately and designated as Ordnance Pamphlet 1064A.

Ordnance Pamphlets 1064 and 1064A are written for beginners on the Computer Mark 1, but they are not intended for beginners in fire control. These pamphlets assume that although the reader knows very little about the Computer Mark 1, he is already acquainted with some of the simpler mechanical computers, and with the fire control problem.

The reader is assumed to be thoroughly familiar with the basic fire control mechanisms described in OP 1140.

The reader is also assumed to be familiar with the general nature of the fire control problem. Many of the fundamentals of fire control are discussed in this pamphlet, but usually on the assumption that they are already fairly well understood and need only a brief review.

All diagrams in this OP are presented in such a way that little or no previous experience in reading schematic diagrams is necessary.

NOTE: Since the majority of the Computers Mark 1 in service are Mark 1 Mod 7, and since the other Computers Mark 1 are very similar to the Mod 7, all references to the Computer Mark 1 in this OP apply to a Computer Mark 1 Mod 7 equipped with a Star Shell Computer Mark 1, a Selector Drive Mark 1, and a Target Course Indicator Mark 1.

The chapter on Modification Differences describes how other modifications differ from the Mod 7.

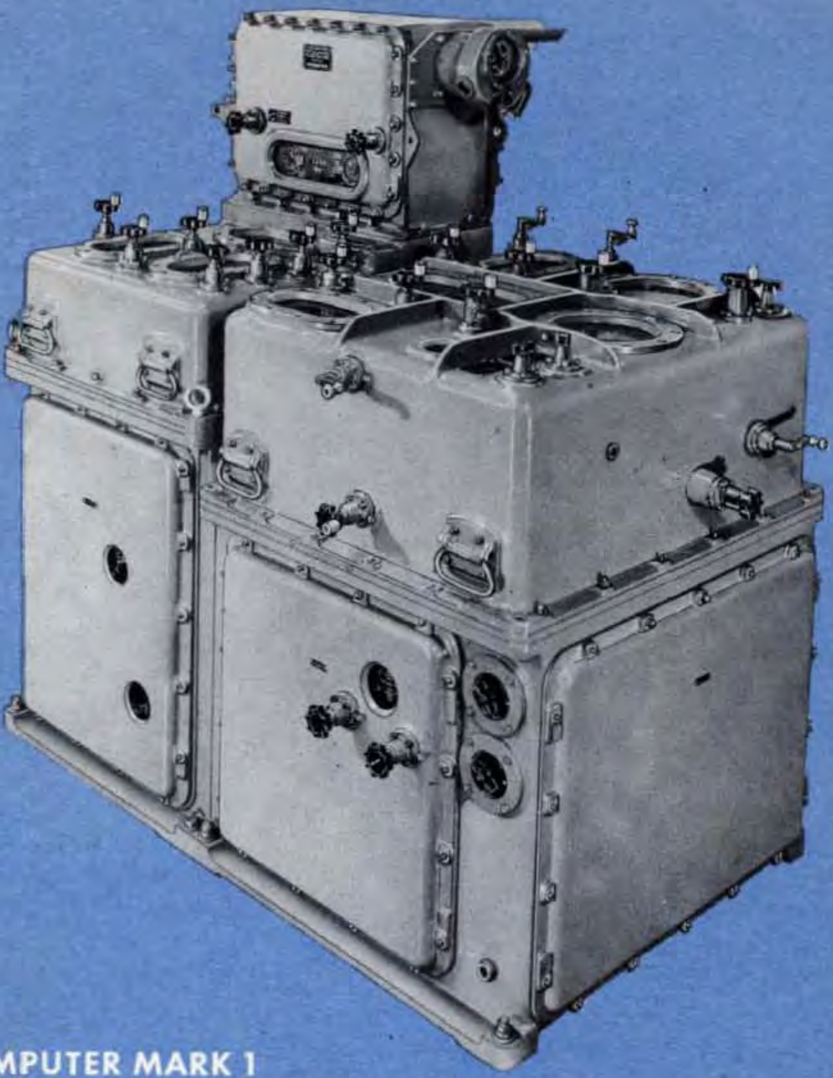
PART 1

GENERAL DESCRIPTION

The General Description is intended to give an over-all picture of the Computer Mark 1, and its place in the Gun Director Mark 37 System of fire control. The General Description familiarizes the reader with the main features of the Computer, and the fire control problem it solves, before he tackles the Detailed Description.

Those readers whose interest in the Computer Mark 1 is only general, and does not extend into the details of operation and maintenance, will probably find that the General Description contains most of the information they need.

The General Description includes the following subjects:

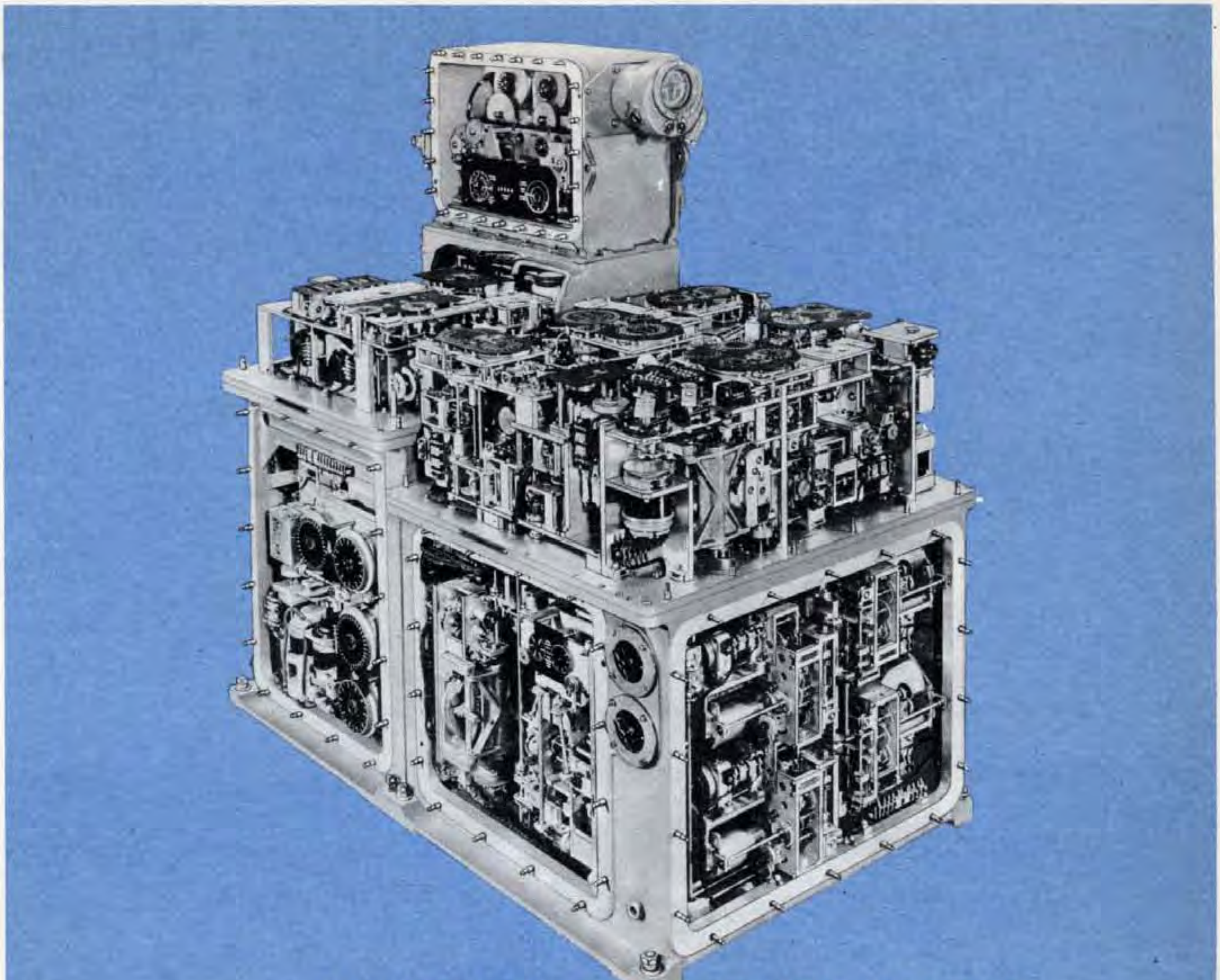


THE COMPUTER MARK 1

The Computer Mark 1 is the mechanical brain of the Gun Director Mark 37 System of Automatic Fire Control. This system controls the fire of the 5"/38 cal. dual-purpose guns against both air and surface targets. The system is also used to control 40-mm. guns at short ranges and main battery guns in barrage fire. Later modifications of the Computer Mark 1 calculate gun orders for 5"/54, 6"/47, and 8"/55 cal. batteries.

The Computer Mark 1 computes continuous gun orders containing corrections for all the significant factors affecting anti-aircraft and surface fire. The corrections allow for the motion of Ship and Target during the time the projectile is in flight; for the curvature of the projectile path caused by gravity, drift, and wind; for pitch and roll of the Ship; and for a number of other factors.

These gun orders, a fuze setting order, and parallax corrections, are continuously transmitted from the Computer to the gun mounts. At the mounts, these orders are used to point the guns continuously and to time the fuzes so that the projectiles will explode at the predicted position of the target.



COMPUTER MARK 1 WITHOUT ITS COVERS

At first the Computer Mark 1 looks like a chaotic maze of gearing and motors, but actually it is an orderly collection of connected basic mechanisms. The important thing to realize is that the thousands of gears and shafts which look so complicated do one of the simplest jobs in the Computer. Most of them just connect one mechanism to another. The mechanisms themselves—component solvers, integrators, multipliers, differentials and so on—do the computing. The gears and shafts merely transmit motion from one mechanism to another so that all the mechanisms in the Computer work together as a big network. The gearing is fairly intricate in construction, but the job it does is simple.

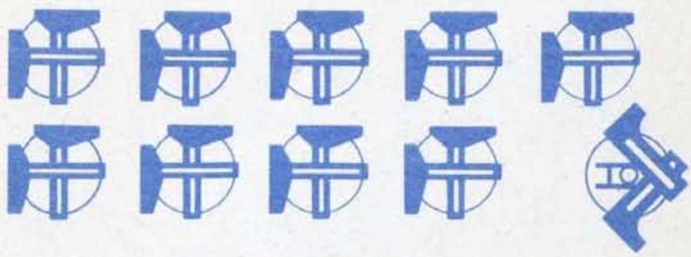
One does not have to be a mechanical engineer to understand the Computer Mark 1. The detailed description of the Computer breaks it down into about four sections which can be understood one at a time without too much difficulty. It is a good idea to become very familiar with this material because it contains information that will be useful in operating, testing, setting, and maintaining the Computer.

Here are the BASIC MECHANISMS

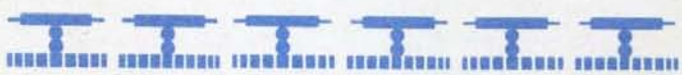
The Computer Mark 1 is made up almost entirely of the Basic Fire Control Mechanisms described in OP 1140. If the Basic Mechanisms were taken out of the Computer there would be nothing left but the case, a few special mechanisms, the shaft assemblies, and the wiring. Anyone who knows the Basic Mechanisms described in OP 1140 already knows a lot about the Computer Mark 1.

The Computer Mk 1 Mod 7 contains the following Basic Mechanisms:

9 COMPONENT SOLVERS AND 1 VECTOR SOLVER

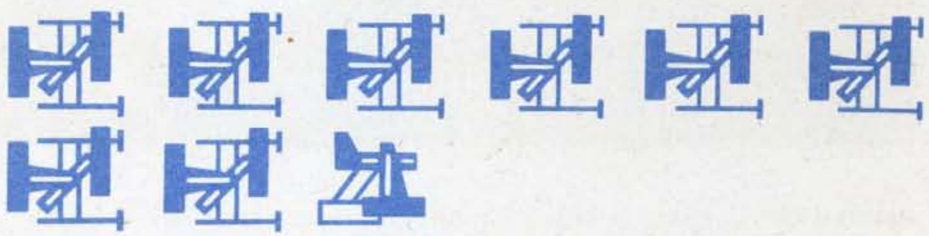


6 DISK INTEGRATORS



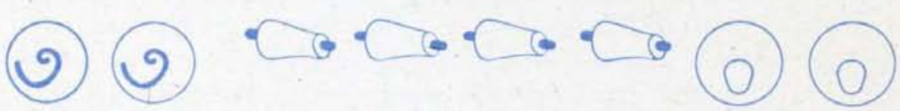
4 COMPONENT INTEGRATORS

9 MULTIPLIERS



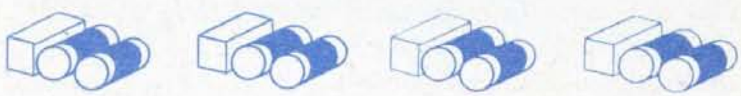
6 COMPUTING MULTIPLIERS

8 CAMS IN ADDITION TO THE CAMS IN THE COMPONENT SOLVERS AND MULTIPLIERS.



5 SINGLE-SPEED RECEIVERS

4 DOUBLE-SPEED RECEIVERS



in the COMPUTER MARK 1

10 SINGLE-SPEED TRANSMITTERS

10 DOUBLE-SPEED TRANSMITTERS

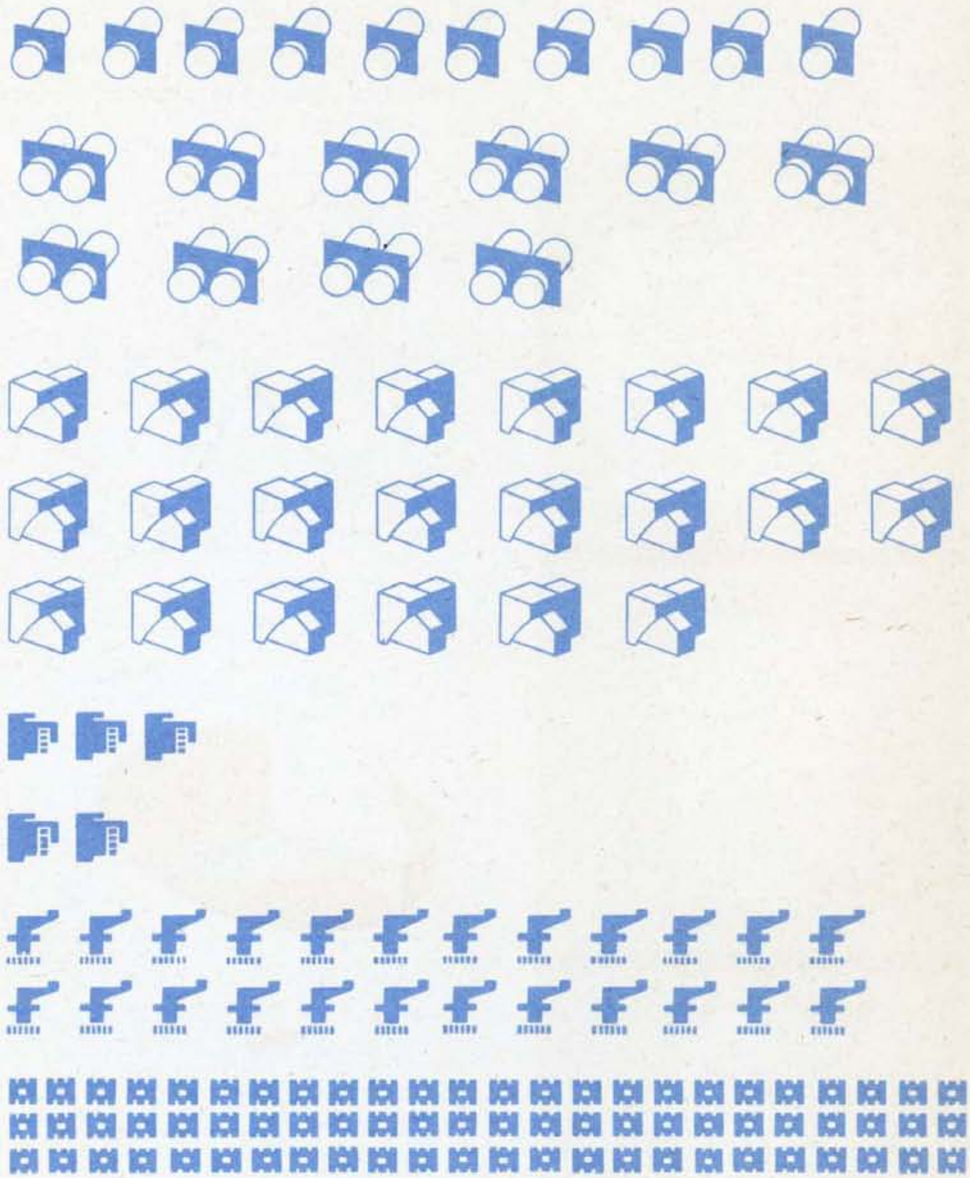
22 FOLLOW-UP CONTROLS

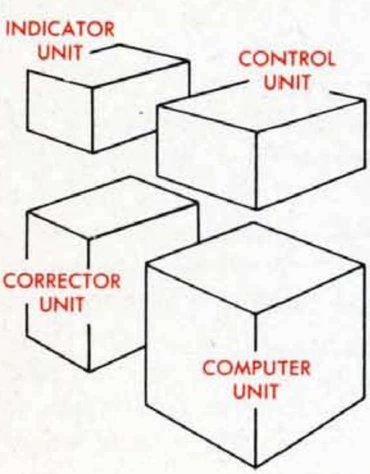
3 SOLENOID CLUTCHES

2 SOLENOID LOCKS

24 HANDCRANKS

MORE THAN 150 DIFFERENTIALS





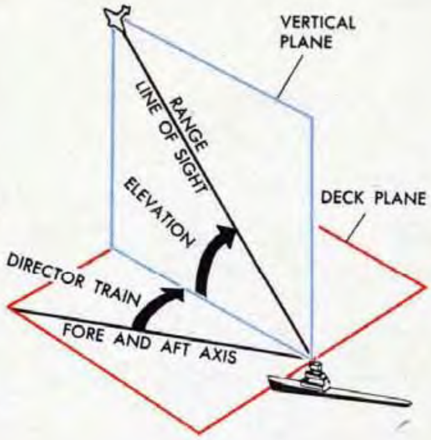
In order that the Computer Mark 1 may be installed more easily in certain types of ships, it is so constructed that it can be separated into four installation units.

Thousands of man-hours of skilled labor are required to make and assemble the parts of this Computer.

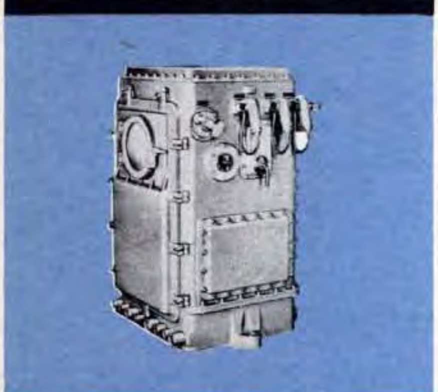
The finished instrument costs about $75,000. It should be treated with care.

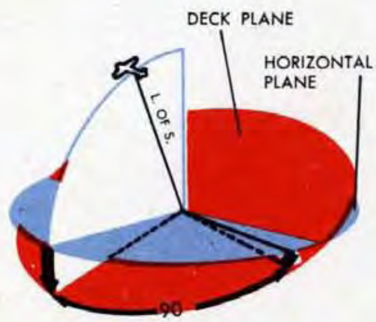
COMPANION INSTRUMENTS of

The Computer Mark 1 is one of a group of instruments which are connected together to form a system of anti-aircraft and surface fire control known as the Gun Director Mark 37 System.

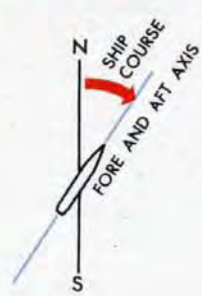


The Gun Director Mark 37 is the eyes of the system. After picking up the Target, the Director observes its location in relation to Own Ship. The Director measures the Target's Range and Elevation in relation to the deck plane. It also measures the Bearing in the deck plane clockwise from the bow of Own Ship to the vertical plane through the Line of Sight. This angle is called Director Train.

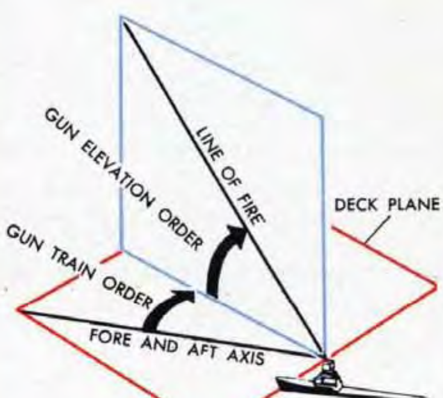




The Stable Element Mark 6 measures the inclination of the deck in relation to the horizontal plane and the Line of Sight.



The Gyro Compass measures Own Ship Course.

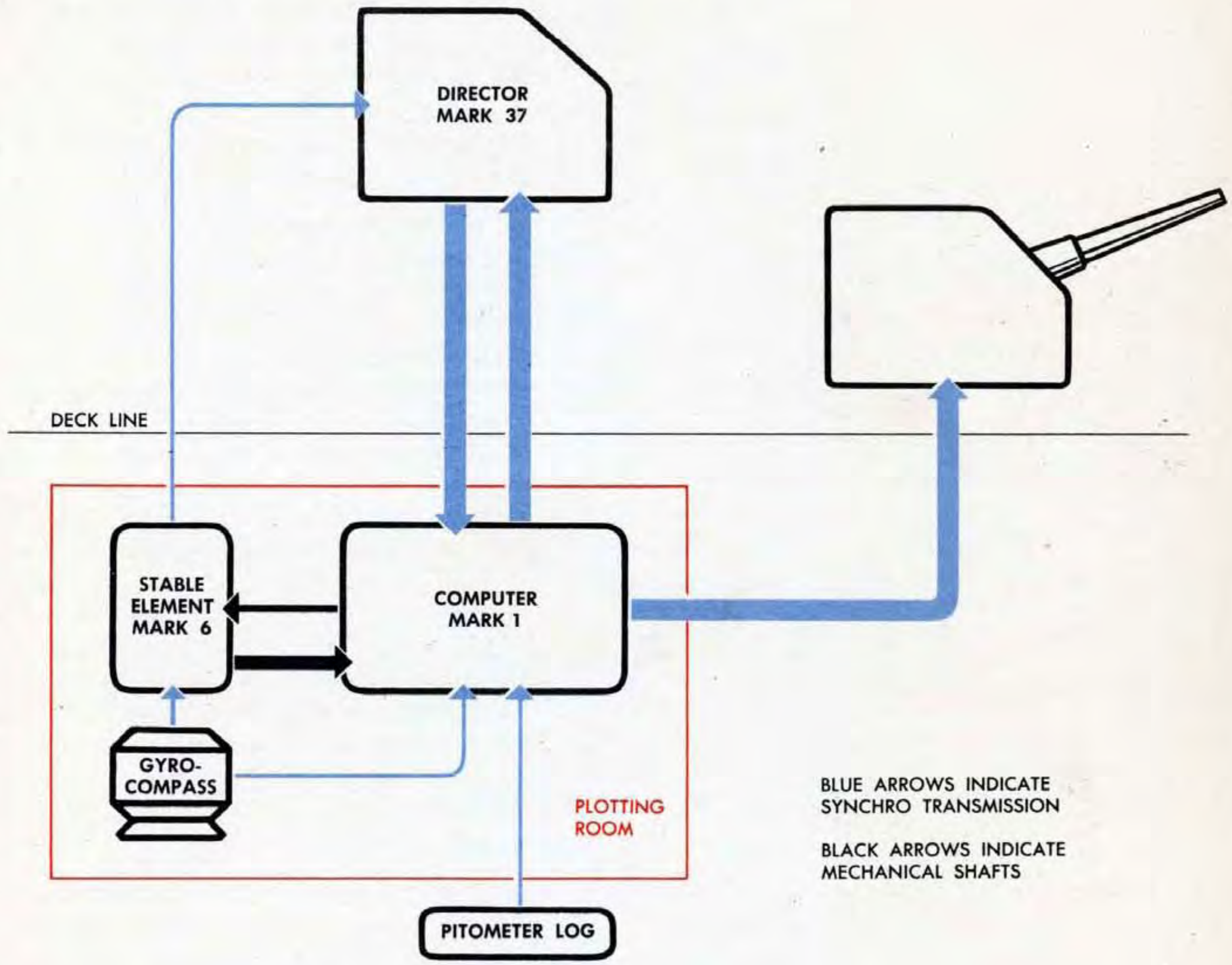


In the mounts, there are mechanical, electrical, or electrohydraulic mechanisms which keep the guns pointed and the fuzes set to agree with the gun and fuze order signals from the Computer. There are also provisions for introducing parallax corrections where necessary.

the COMPUTER MARK 1

There are a number of other elements in the Gun Director Mark 37 System, including the Pitometer Log which measures Own Ship Speed, a switchboard, and intercommunication telephones.

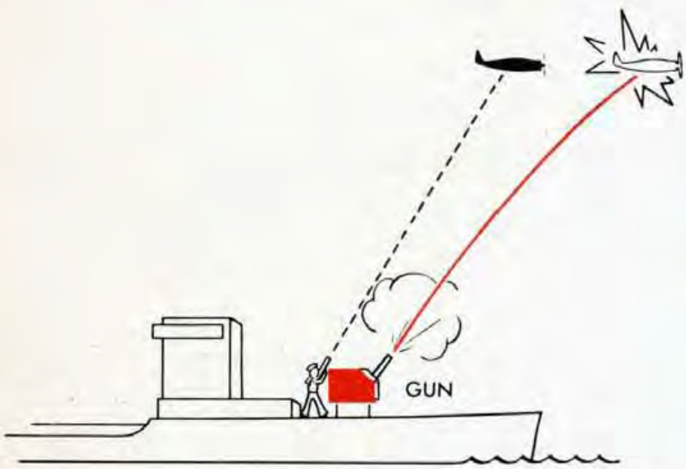
The various instruments are related to one another like this:



The Director is usually about 30 feet or more above the deck. The guns are located in various places on the deck depending on the type of ship.

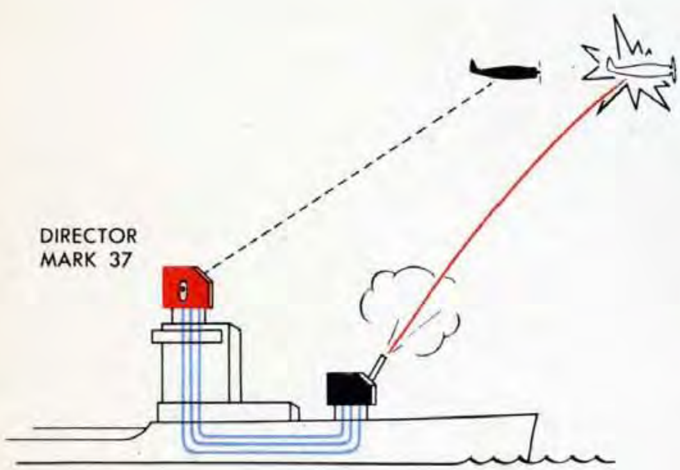
The Computer and the Stable Element stand together in the plotting room of the ship and are connected mechanically by shafts. The Gyro Compass and the switchboard are also in the plotting room. Most of the instruments in the system are connected electrically by synchro transmission.

The place of the COMPUTER MARK 1 in the GUN DIRECTOR MARK 37 SYSTEM



Since the Computer Mark 1 is part of the Gun Director Mark 37 System, it is essential to know the function of each unit of this system in order to understand the Computer itself. The Mark 37 System can best be built up by starting with the guns alone.

It would be possible to direct the fire of the guns from each gun mount, independently of other mounts or observation stations. But fire control from the mounts alone has several disadvantages. Visibility from the mount is often bad because of the smoke. Observation of surface targets is restricted by the relatively small height of the mounts above the water line. Also, it is difficult to coordinate the fire of several gun mounts when each is separately controlled.

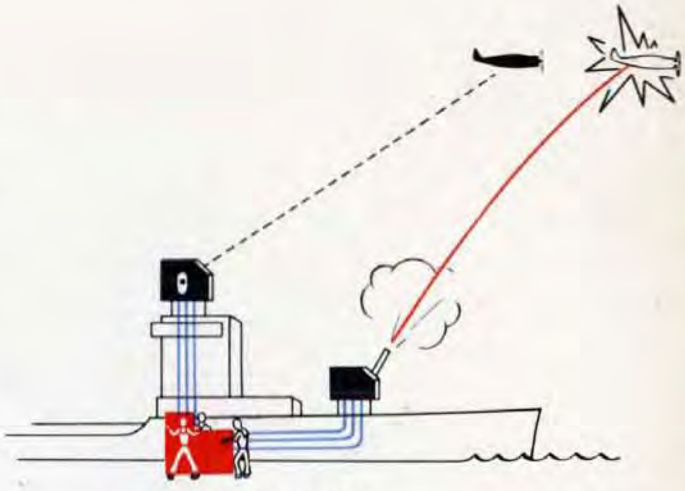


These difficulties are overcome by having a Gun Director aloft, high enough for the Director Crew to see above the smoke and to observe surface targets at great distances. With a Gun Director, the fire of all the gun mounts can be coordinated.

Firing with the combination of mounts and a Gun Director is better than firing from the gun mounts alone. In such a simple fire control system, however, all corrections for motion of Ship and Target, curvature of the projectile path, and the pitch and roll of the Ship would have to be made by guess work.

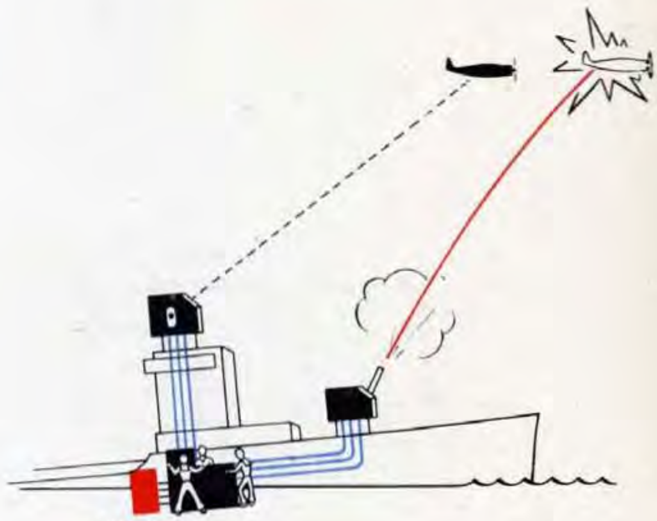
An instrument is needed to compute all these corrections instantaneously and continuously. In the Gun Director Mark 37 System of fire control, the instrument that fills this need is the Computer Mark 1.

The Computer Mark 1 is located in the plotting room. In the plotting room the Computer is better protected than it would be in the Director or at the gun mount. If the Director is put out of action, the Computer can still continue to function. In fact, one of the features of the Computer Mark 1 is that, without any Director inputs, it can generate enough of the values normally received from the Director to track a surface target.

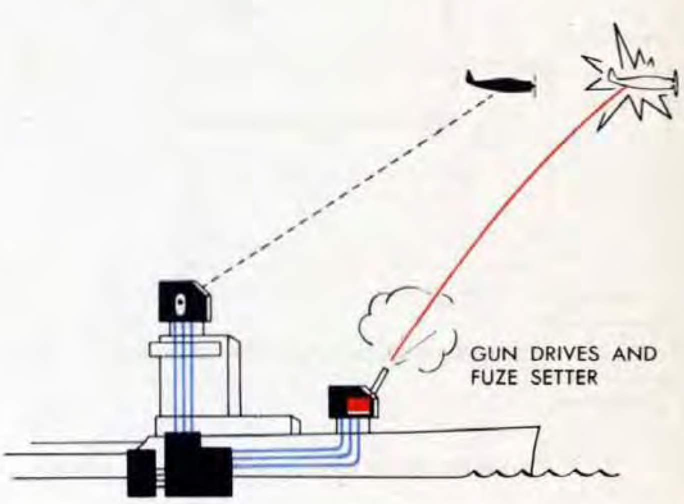


The Director and Computer in the Gun Director Mark 37 System are able to track the Target and compute predictions for relative motion and for curvature of the projectile path, but by themselves they cannot allow for pitch and roll of Own Ship.

In order to fire continuously during pitch and roll, the Director, Computer, and guns must be corrected continuously for the effects of deck inclination. To measure deck inclination, the Gun Director Mark 37 System uses the gyro mechanism called the Stable Element Mark 6. The Stable Element measures the amount of deck inclination from the horizontal plane with reference to the Line of Sight.



Because of the number and variety of the factors which enter into the fire control problem, the outputs of the Computer Mark 1 are continually changing. In order to keep the guns pointed in accordance with these varying orders from the Computer, there are electrical or electrohydraulic mechanisms at the gun mounts which receive the changing signals and control power drives. The power drives point the guns continuously by turning the whole mount in train, and moving the guns themselves in elevation. Another electrical mechanism, the Fuze Setter, receives the fuze order from the Computer Mark 1 and automatically sets the fuzes of the projectiles as they wait to be loaded.



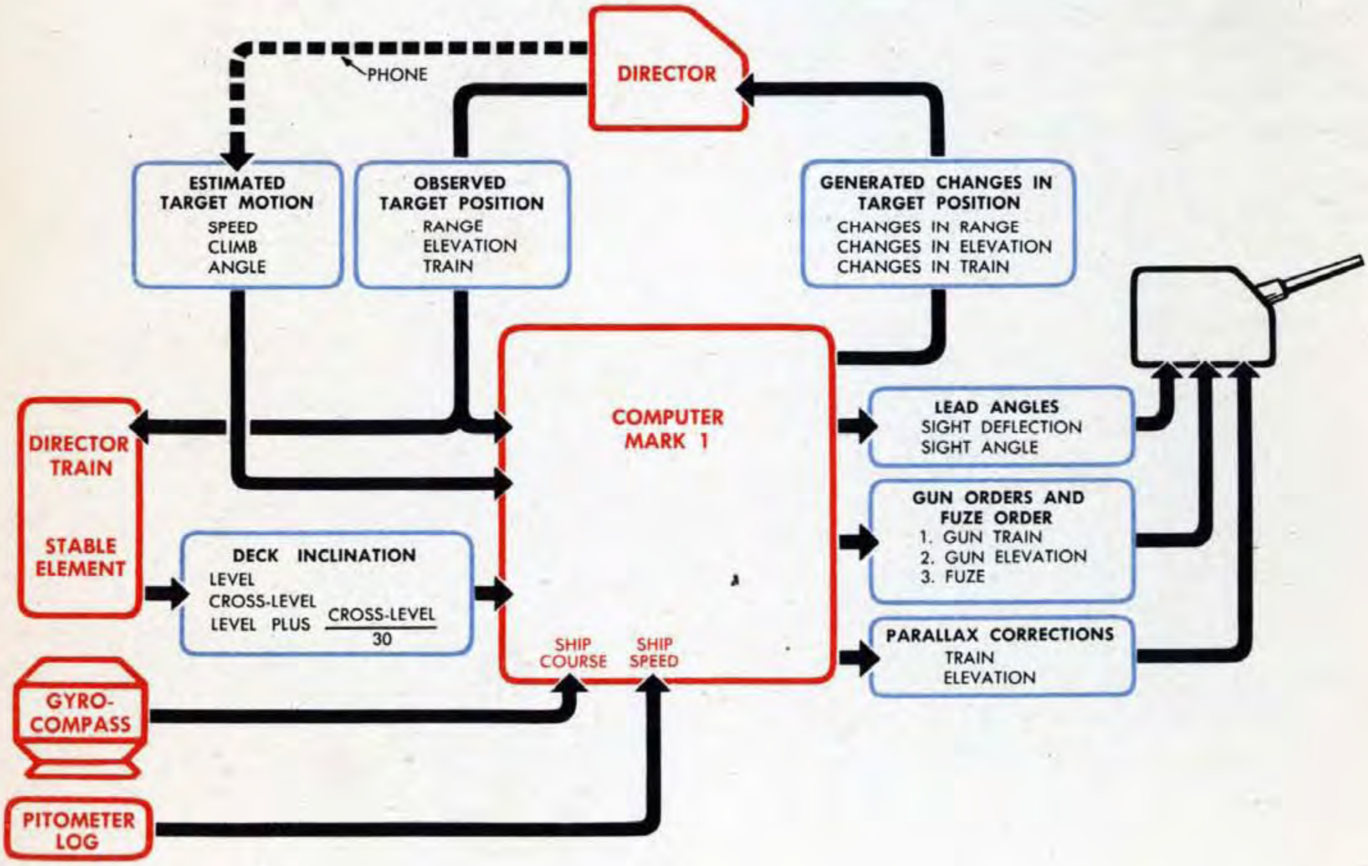
What the COMPUTER MARK 1 does in the

In the Gun Director Mark 37 System, all the instruments except those at the gun mounts are used to furnish inputs to the Computer Mark 1.

The Director Crew "pick up" a target with the telescopes and Range Finder. By turning their handwheels and the Range Knob, they keep their crosshairs continuously on the target, and transmit values of Range, Director Elevation, and Director Train to the Computer.

The Stable Element receives the value of Director Train from the Computer, and continuously measures the angles of Level and Cross-level, which are the vertical components of deck inclination from the horizontal, in and at right angles to the plane of sight. Level, Cross-level, and Level plus a function of Cross-level, are transmitted mechanically from the Stable Element to the Computer.

Besides the inputs from the Director and the Stable Element, the Computer receives the values of Ship Speed from the Pitometer Log, Ship Course from the Gyro Compass, and *estimates* of Horizontal Target Speed, Target Course, and Rate of Climb, by phone from the Control Officer in the Director.



GUN DIRECTOR MARK 37 SYSTEM

Using these inputs together with some other hand inputs, the Computer goes to work. Briefly, this is what it does:

1 The Computer Mark 1 computes and transmits to the gun mounts continuous Gun and Fuze Orders containing:

a Corrections for movement of Ship and Target during the time of flight of the projectile.

b Corrections for curvature of the projectile path caused by gravity, drift, wind, and changes in initial velocity.

c Corrections for the effects on the gun of roll and pitch of the Ship.

2 The Computer computes continuous values of the Lead Angles in elevation and deflection. These Lead Angles are called Sight Angle and Sight Deflection. They are transmitted electrically to the gun mounts to offset the gun sights.

3 The Computer Mark 1 computes and transmits two Parallax Corrections, which may be applied at the individual gun mounts to compensate for differences in location of guns and Directors.

4 Through the Star Shell Computer, gun and fuze orders are computed for firing star shells to illuminate surface targets which the Computer Mark 1 is tracking.

5 The Computer corrects the estimated Target Motion inputs. It does this by generating changes of Range, Director Elevation, and Director Train which are transmitted electrically to the Director to drive the Director sights. By comparing the generated Computer values with the observed Director values of Range, Elevation, and Train, the Computer checks and corrects the original estimates of Target Horizontal Speed, Course, and Rate of Climb, and puts accurate values of these three quantities into the computing mechanism. When the estimated values are correct, the generated quantities keep the Director sights on Target. This process of correcting the Target Motion estimates is called Rate Control.

NOTE:
Unless the Target goes into a dive attack, Rate of Climb usually has a value close to zero. For this reason it is seldom necessary for an estimate of Rate of Climb to be phoned down from the Director. Instead, Rate of Climb can simply be set at zero, unless dive attack is indicated. The correct value of Rate of Climb will be computed during Rate Control.

For convenience, this special characteristic of the Rate of Climb estimate has been ignored throughout the General Description.

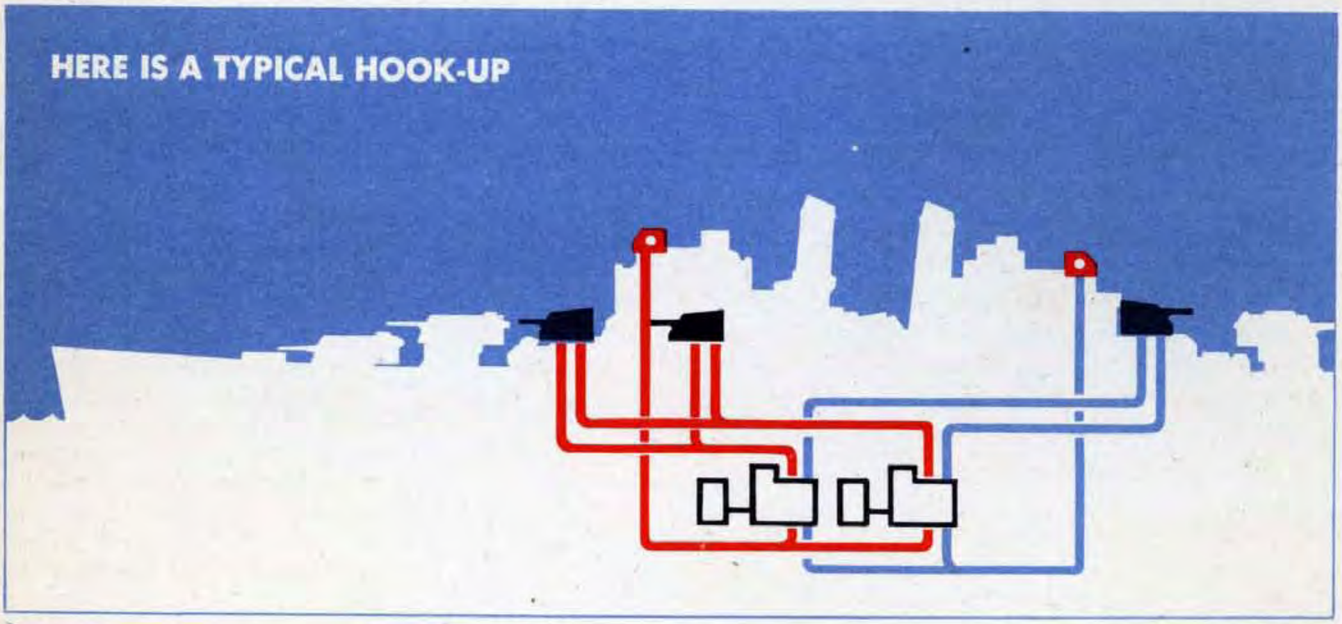
The ships using the COMPUTER MARK 1

The Computer Mark 1 and the other elements of the Gun Director Mark 37 System are used on the following types of ships:

Destroyers, all types after DD409 and some earlier
Light and heavy cruisers, after CL51 and CA68
Battleships, after BB55 and some earlier
Aircraft carriers of the types CV9 and CVB41
Some auxiliary vessels

Sometimes the computers are installed singly, sometimes in pairs, sometimes in groups of four, depending mainly on the type of ship.

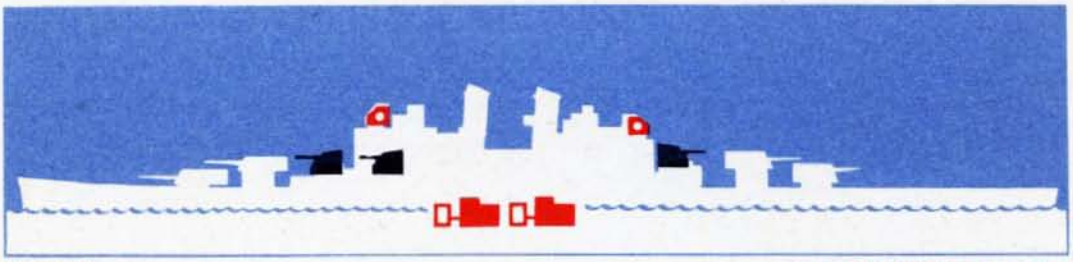
On ships having more than one computer, each computer has a gun director. The installation is usually designed so that any director can be connected to any computer, and any computer can be used with any gun or group of guns. The limits of the possible cross-connection of directors, computers and guns are the limitation of shipboard wiring, and the fact that a director can control only those guns training in about the same arc of bearing as the director.



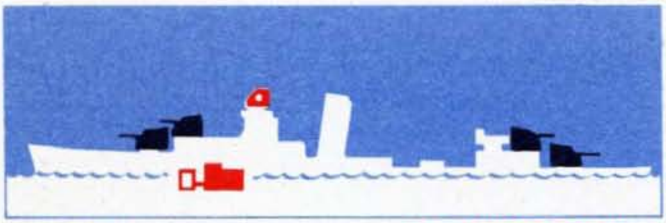
Here are typical locations of the Gun Director Mark 37 System on various kinds of ships. There are other variations. These are only a few examples.

AIRCRAFT CARRIER — 2 COMPUTERS MARK 1

BATTLESHIP — 4 COMPUTERS MARK 1



CRUISER — 2 COMPUTERS MARK 1



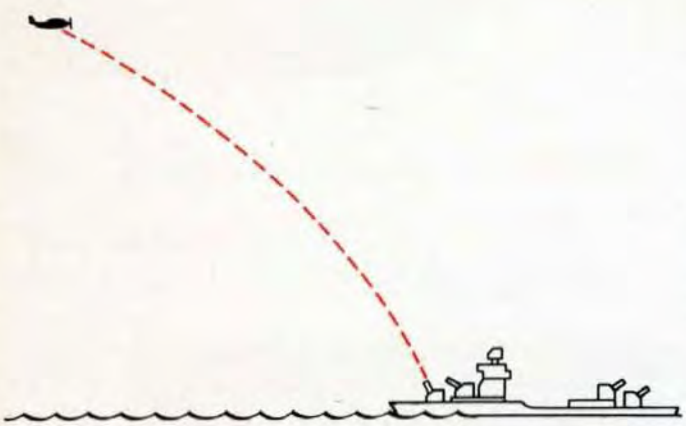
DESTROYER — 1 COMPUTER MARK 1

Types of TARGETS and ATTACK

Air targets

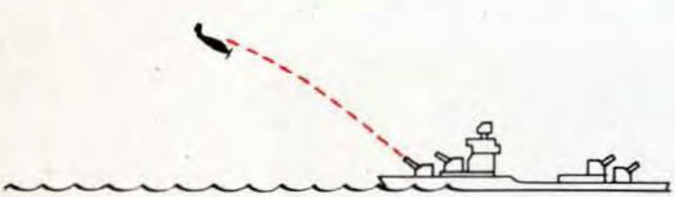
The Computer Mark 1 is primarily designed for use against air targets.

It computes accurate gun orders for Continuous Fire against nearly all types of air targets, such as:



1 High-level Horizontal Bombers

2 Low-level Torpedo Planes



3 Dive Bombers attacking Own Ship

4 Dive Bombers attacking other ships (when the vertical component of Target Speed does not exceed −250 knots).

The Computer may also be used for antiaircraft barrage fire by the 5″ guns, or by the main battery guns.

Surface and land targets

The Computer also computes accurate gun orders for Continuous or Selected Fire against all types of surface targets:

1 Other ships, destroyers, cruisers, etc.

2 High-speed torpedo boats which travel at speeds outside the limits of the main battery computers.

3 Stationary land targets such as shore installations, and moving land targets such as tanks.

The Computer may also be used for barrage fire against a surface target both by the 5″ guns and the main battery guns.

Types of SELECTED FIRE

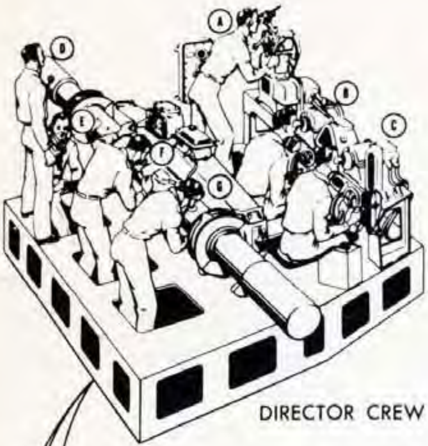
Two kinds of Selected Fire are possible in this system:

1 Selected Level Fire, in which the value of Level may be selected at either the Director or the Stable Element.

2 Selected Cross-level Fire, in which the value of Cross-level is always selected at the Stable Element.

In Selected Level Fire against a surface target the Computer Mark 1 can produce gun orders without Director inputs.

AUTOMATIC FIRE CONTROL in the



DIRECTOR CREW

The Gun Director Mark 37 System is referred to as a system of Automatic Fire Control for continuous fire. However, it is important to realize that it falls considerably short of completely automatic fire control. It falls short in ways which require skill in operation. The role of the operating personnel in the Mark 37 System is not predominantly stand-by or in any sense auxiliary. Their functions are vitally important just because the System does leave gaps which must be filled in by the operating personnel.

Here is a list of the main functions of a fire control system, showing which functions are accomplished automatically in the Gun Director Mark 37 System, and which require manual operation by the crews.

1 Locating the target

There are two methods of locating targets in the Gun Director Mark 37 System, optical and radar. Neither of these is automatic. Both systems depend on observation by the operating personnel. The use of either system is a matter of discretion on the part of the officer in charge of the Director.

2 Tracking the target

Tracking is far from automatic. The sights must be kept on the Target by the Pointer, Trainer and Range Finder Operator, aided by some outputs from the Computer.

3 Communicating information

In the Gun Director Mark 37 System most information is communicated automatically by synchro transmission. Estimated values, however, are transmitted by phone.

4 Correcting the target motion estimates

The Mark 37 System has no way of measuring Target Motion directly. The Computer crew puts the *estimates* of Target Motion into the Computer, as values of the Horizontal Target Speed, Target Angle, and Rate of Climb. The Computer computes Relative Motion Rates and uses them to generate changes of Range, Elevation, and Bearing, which it compares with the Observed Changes of these three quantities. The differences between the Generated and the Observed Changes of each of these quantities are used by the Computer to correct the estimated values of Target Motion.

COMPUTER CREW

GUN CREW

GUN DIRECTOR MARK 37 SYSTEM

When the Target Motion values are correct, the Computer will automatically generate Changes of Range, Elevation, and Bearing which will be equal to the Observed Changes.

The process of using the difference between the Generated and the Observed Changes of Range, Elevation, and Bearing to correct estimated Target Motion is called Rate Control. It is the main job in operating the Computer. Correcting these estimates requires skill on the part of Computer Operators, and knowledge of how the fire control problem is solved in the Computer Mark 1.

After Rate Control is completed, the target values are correct and the Computer automatically computes correct Relative Motion Rates and generates correct Changes of Range, Elevation, and Bearing, which keep the Director sights on Target AS LONG AS THE TARGET CONTINUES IN THE SAME DIRECTION AT THE SAME SPEED.

As soon as the Target changes its course or speed, Rate Control must be started all over again.

5 Predicting

Prediction is automatic in the Computer Mark 1 except for two hand inputs. These two inputs are the value of Initial Velocity, and the value of Dead Time. Dead Time is time between the setting of the fuze and the firing of the gun.

6 Stabilizing the guns and the director

The stabilizing of both the Director sights and the guns is fully automatic in the Director Mark 37 System.

7 Pointing the guns

Pointing the guns in response to signals from the Computer can be fully automatic.

8 Setting the fuzes

Fuzes are set automatically by the Automatic Fuze Setter.

9 Loading the guns

The projectiles must be taken from the setter and loaded into the gun by hand.

The sections of the COMPUTER MARK 1

The Computer Mark 1 has three main jobs. The first is to correct the estimated inputs of Horizontal Target Speed, Target Angle, and Rate of Climb and so establish three correct Relative Motion Rates. This job can be called *establishing the correct Relative Motion Rates* and is done in the Tracking Section.

The second main job is to compute two lead angles and a fuze order which will keep the guns pointed so that the projectile and Target will meet at the end of the Time of Flight. These computations may be called *establishing the Line of Fire* from a horizontal deck. This second job is done by the Prediction Section.

The third main job is to *stabilize the Line of Fire*. This is done by the Trunnion Tilt Section, which computes corrections to offset the effect of tilt of the gun trunnions on the Line of Fire.

There are four sections in the Computer Mark 1:

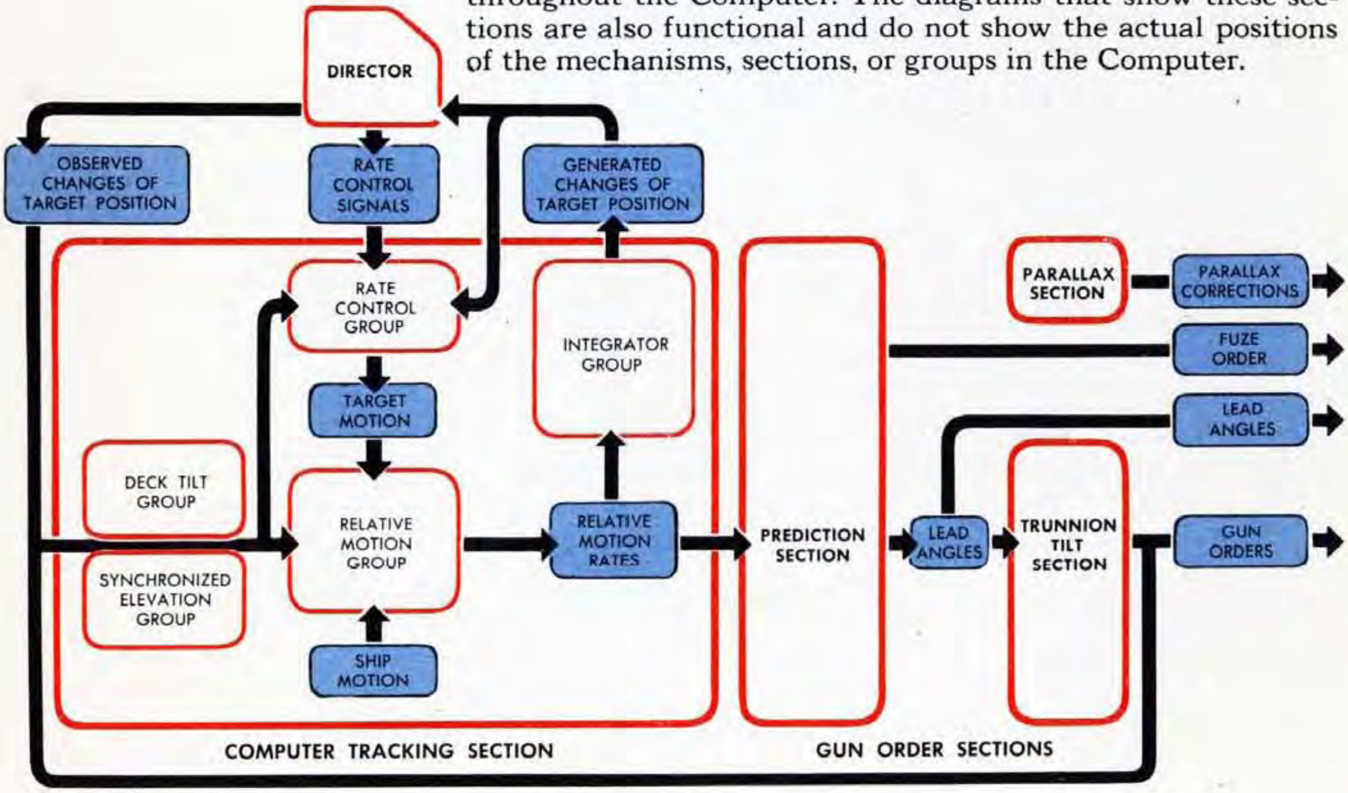
1 THE TRACKING SECTION
2 THE PREDICTION SECTION
3 THE TRUNNION TILT SECTION
4 THE PARALLAX SECTION

The Tracking Section can be divided into five groups:

1 The Deck Tilt Group
2 The Relative Motion Group
3 The Integrator Group
4 The Rate Control Group
5 The Synchronize Elevation Group

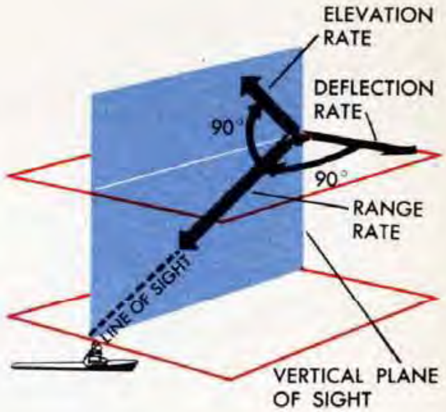
The Parallax Corrections are not included in the Gun Orders but are transmitted separately to the guns.

This grouping of the sections is merely a functional grouping. The mechanisms that form each section are actually scattered throughout the Computer. The diagrams that show these sections are also functional and do not show the actual positions of the mechanisms, sections, or groups in the Computer.



THE TRACKING SECTION

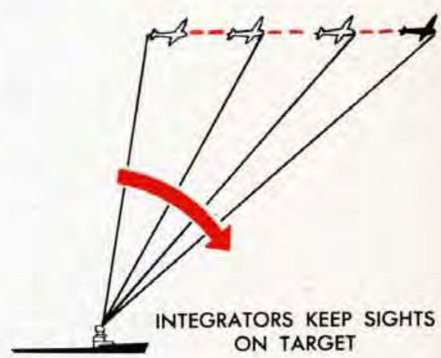
The Relative Motion Group of the Computer Mark 1 combines the motions of Own Ship and the Target into three rates of Relative Motion in relation to the Line of Sight.



The Integrator Group uses these rates to generate changes of Target Position in Range, Elevation, and Bearing. These changes are continuously transmitted to the Director to position the telescopes and the Range Finder.

If the generated values of Target Position do not keep the sights on the Target, the operators in the Director press their Rate Control keys and turn their handwheels to keep the sights on the Target.

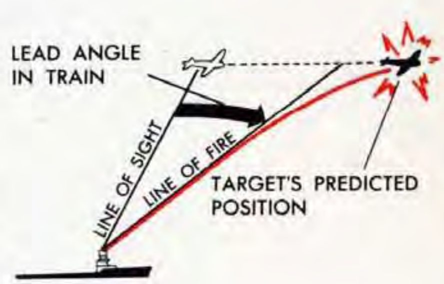
The turning of the handwheels in the Director with the Rate Control keys closed sends Rate Control corrections to the RATE CONTROL GROUP in the Computer.



The Rate Control Group converts these Range, Elevation, and Bearing rate corrections into corrections to the values of Target Motion, and puts the corrected values of Target Motion into the Relative Motion Group. The values of Target Motion in the Relative Motion Group initially were estimates made by the Control Officer.

The Deck Tilt and Synchronize Elevation Groups are each used to refer one value from the deck plane to the horizontal plane. The Deck Tilt Group computes the correction necessary to convert Director Train in the deck plane to Relative Target Bearing in the horizontal plane. The Synchronize Elevation Group converts Director Elevation above the deck to Target Elevation above the horizontal.

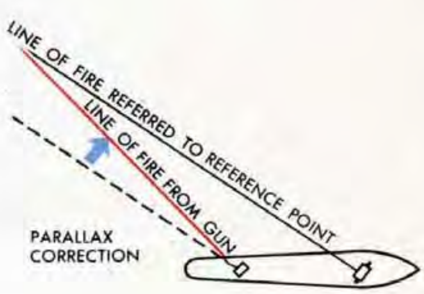
THE PREDICTION SECTION uses the three Relative Motion Rates to compute the amount the guns must lead the Target. It computes two lead angles and a fuze setting order.



The Lead Angles include computations for the change in Target Position while the projectile is in the air and for the projectile's curved path. To obtain the Lead Angles, the Prediction Section computes the Target Position at the end of the Time of Flight and corrections for the effect of gravity, drift, wind, and changes in initial velocity on the projectile path.

The Fuze Setting Order includes a correction for the change in Range during the time the projectile is being loaded.

THE TRUNNION TILT SECTION computes corrections for the effects of pitch and roll on the gun trunnions. The lead angles and the Trunnion Tilt Corrections are combined with Director Elevation and Train to form the two Gun Orders.



THE PARALLAX SECTION computes Train and Elevation Parallax Corrections for a horizontal distance of 100 yards along the fore and aft axis. These two Parallax Corrections may be transmitted separately to the guns and Directors. Each gun or Director may use a fraction of each correction according to its distance from the Reference Point.

A SIMPLIFIED ACCOUNT OF TRACKING, PREDICTION, AND STABILIZATION

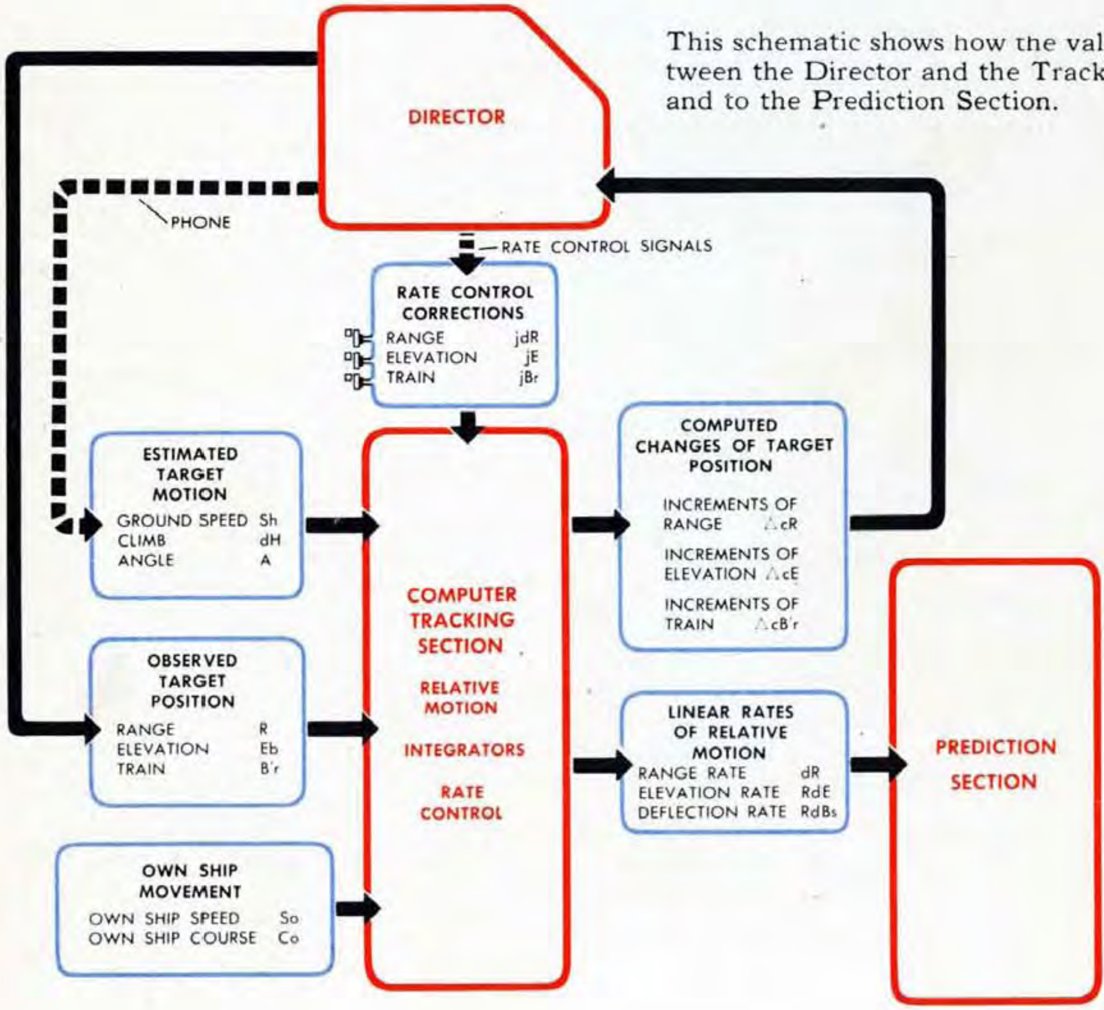
TRACKING the TARGET

It is easier to understand how the Computer tracks a Target and computes gun orders if Own Ship is first considered as being steady, that is, as if Own Ship were neither pitching nor rolling but had its deck horizontal all the time.

On a steady horizontal ship, the Deck Tilt Group, Trunnion Tilt Section, and the Stable Element may be disregarded. Since Parallax Corrections are not included in the Gun Orders, the Parallax Section may also be left out for the moment. With the deck horizontal, only two sections are needed in order to go through tracking and the computation of Gun and Fuze Orders.

The two sections needed are the Tracking and Prediction Sections. In the Tracking Section the Deck Tilt and Synchronize Elevation Groups may be disregarded at this time.

This schematic shows how the values flow between the Director and the Tracking Section, and to the Prediction Section.



1 When a Target is sighted, the Trainer, Pointer and Range Operator in the Director immediately pick it up and continuously measure its *Position* in Range, *R*, Elevation, *Eb*, and Director Train, *B′r*. These three quantities, *R*, *Eb*, and *B′r*, are transmitted electrically to the Computer.

2 The values of Target *Motion* are estimated by the Control Officer and phoned down to the plotting room, where they are set into the Tracking Section by hand by the Computer Crew. The Target Motion values are: Target Horizontal (Ground) Speed, *Sh*, Target Angle, *A*, and Rate of Climb, *dH*.

In addition to the Target Position values and Target Motion values, the Tracking Section receives the values of Ship Speed, *So*, and Ship Course, *Co*.

3 With these three groups of inputs the Tracking Section goes to work. The Relative Motion Group combines Ship and Target Motion into three linear Relative Motion Rates: Range Rate, *dR*, along the Line of Sight, Elevation Rate, *RdE*, perpendicular to the Line of Sight in the vertical plane, and Deflection Rate, *RdBs*, at right angles to the Line of Sight in the horizontal plane.

The Integrator Group uses these Relative Motion Rates to generate continuous Changes of Target Position: Generated Changes of Range, ΔcR, Generated Changes of Director Elevation, ΔcEb, and Generated Changes of Director Train, $\Delta cB'r$. These three quantities are continuously transmitted to the Director. If they keep the sights on the Target, the Relative Motion Rates are correct and the estimates of Target Motion are correct.

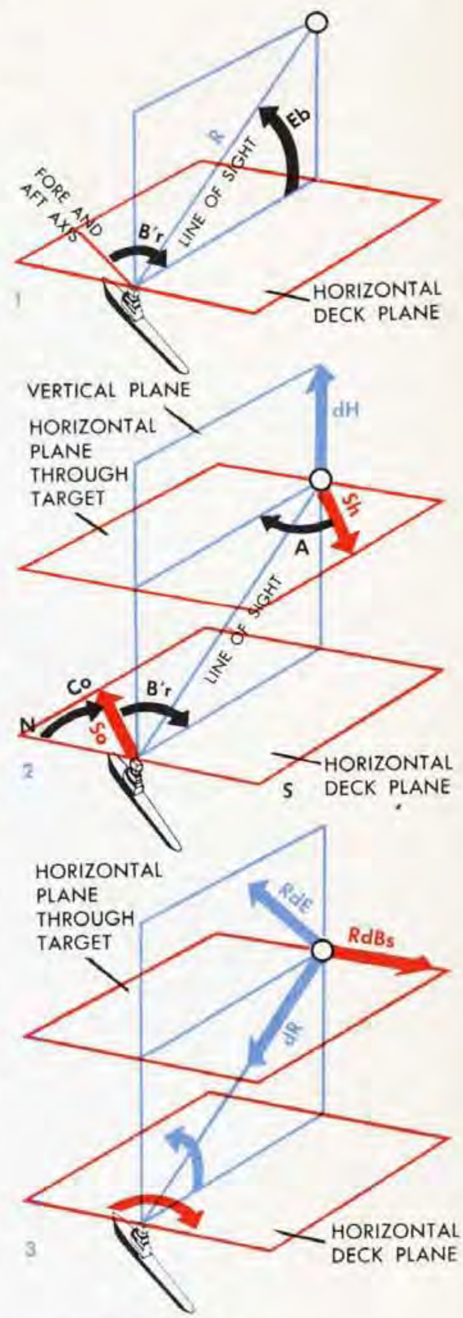
It is impossible to estimate the exact speed and direction of a plane. At the beginning of tracking, the generated quantities, which are based on these estimates, seldom keep the sights on Target.

If the sights do not stay on the Target, the estimates of Target Motion need correction. The Trainer, Pointer, and Range Operator turn their handwheels to bring the sights back on the Target.

By pressing their Rate Control keys as they turn the handwheels, the Director Crew automatically transmit Rate Control signals down to the Computer. These signals allow corrections to go into the Rate Control Group.

The Rate Control Group analyzes these Rate Control Corrections and decides how much the Target Motion estimates must have been wrong to have caused the errors in the generated values. The Rate Control Group then computes a set of more nearly correct Target Motion values.

When the Generated Changes of Target Position, ΔcR, ΔcEb, and $\Delta cB'r$, keep the sights on Target, a tracking solution is reached, and the Computer Crew know that the Target Motion values are correct. The Relative Motion Rates going into the Prediction Section are also correct and will result in accurate predictions.



GENERATED VALUES CONTINUALLY POSITION SIGHTS

NOTE:
In the *General Description*, the Pointer's and Trainer's Handwheels and Range Operator's Range Knob are all referred to as "handwheels." Similarly, the Pointer's and Trainer's Signal Keys and Range Operator's Signal Button are referred to as "signal keys."

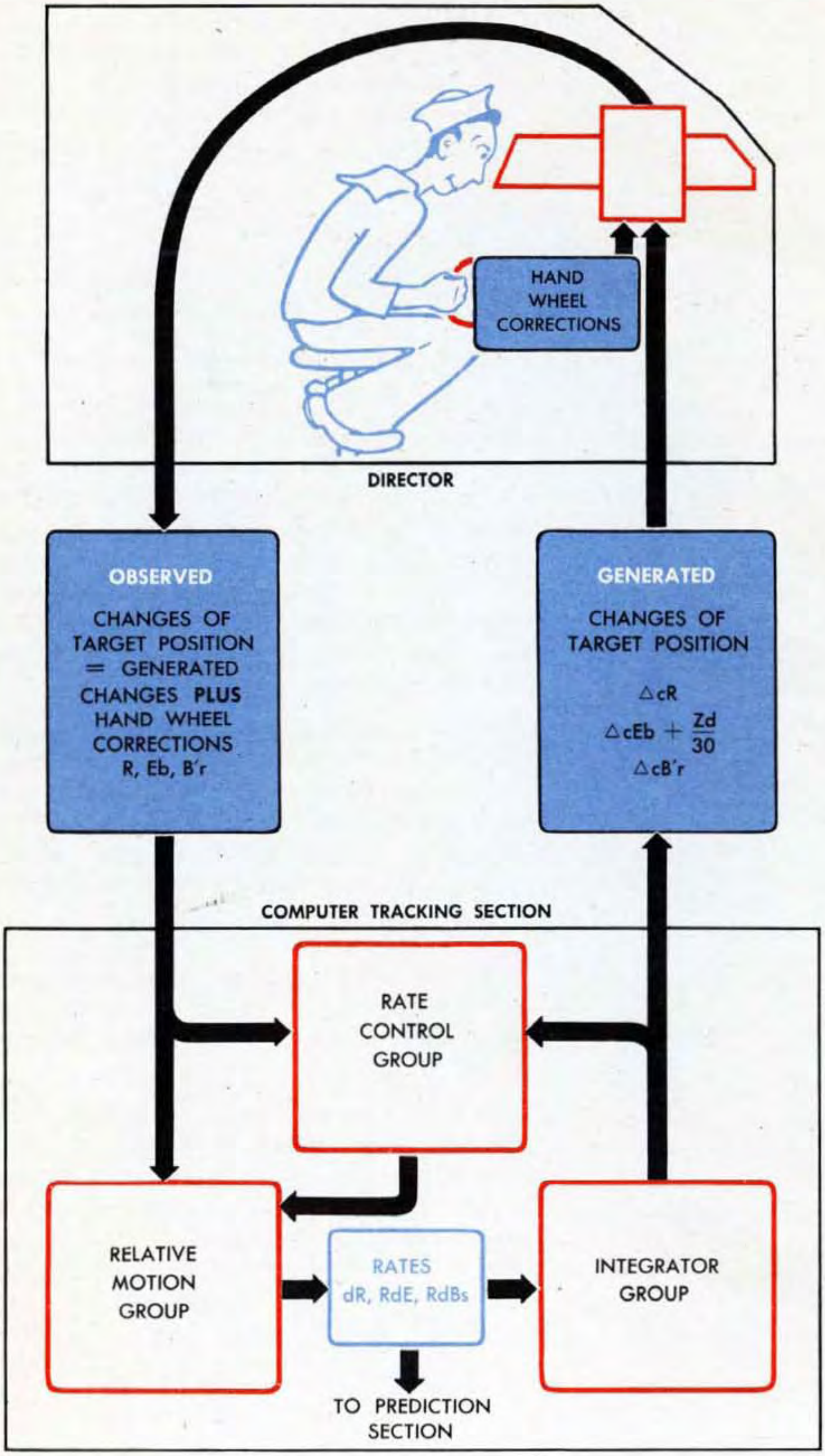
A summary of the tracking cycle for a horizontal deck

In the Gun Director Mark 37 System, tracking on a horizontal deck can be divided into the following operations:

1. Locating a Target and keeping the Director sights on it in order to measure Target Position and transmit this position continuously to the Computer.
2. Estimating the speeds and direction of Target Motion and using these estimates along with other quantities, to compute approximate Rates of Relative Motion.
3. Using the approximate Rates of Relative Motion and other quantities to generate continuous Changes of Target Position.
4. Using the Generated Changes of Target Position to position the Director sights.
5. Comparing the *Observed* Changes of Target Position, from the Director, with the *Generated* Changes of Target Position from the Computer.
6. Using the difference between the *generated* and *observed* values in the Computer to correct the estimates of Target Motion.

When a solution has been reached and the estimates of Target Motion are correct, the Generated Changes of Target Position drive the sights and Range Finder automatically. The Director sights then remain on Target even though the Target is temporarily out of sight. The guns can be fired accurately even though the Target is obscured. As long as the Target continues at the same speed and in the same straight line, the sights will be on the Target when it reappears.

The regeneration of quantities between the Director and Computer is such that, before a solution is reached, the Observed Changes of Range, Elevation, and Director Train, going to the Computer consist of the Generated Changes of those three quantities, plus any corrections the Director Crew put in by hand to keep the sights on Target. After a solution has been reached, the Observed Changes consist entirely of the Generated Changes, no handwheel corrections being necessary.



WHEN TRACKING ON
A HORIZONTAL DECK

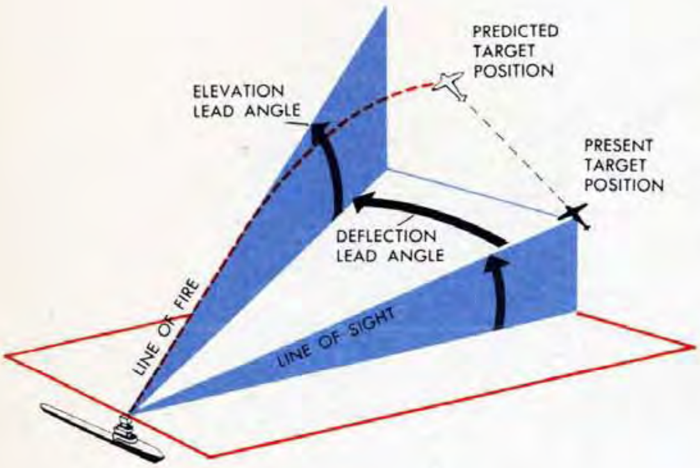
$Eb = E$

$B'r = Br$

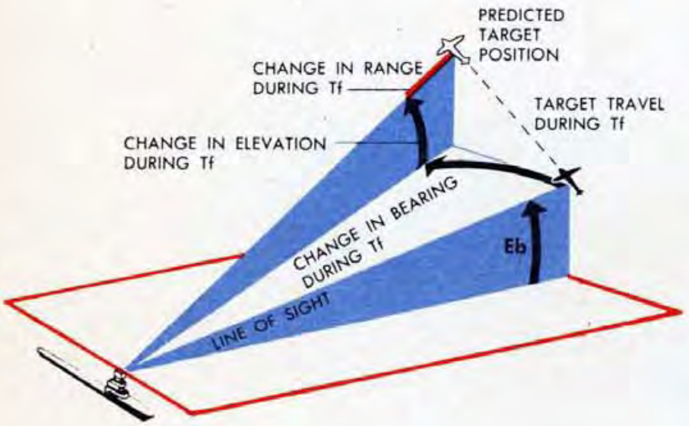
$\triangle cEb = \triangle cE$

$\triangle cB'r = \triangle cBr$

Establishing the LINE OF FIRE



The Relative Motion Rates from the Tracking Section are used in the Prediction Section to compute the Lead Angles. The Lead Angles are the angles in Elevation and Deflection by which the gun must lead the Target in order to make a hit. The Line of Fire is the line along which the gun must be pointed.

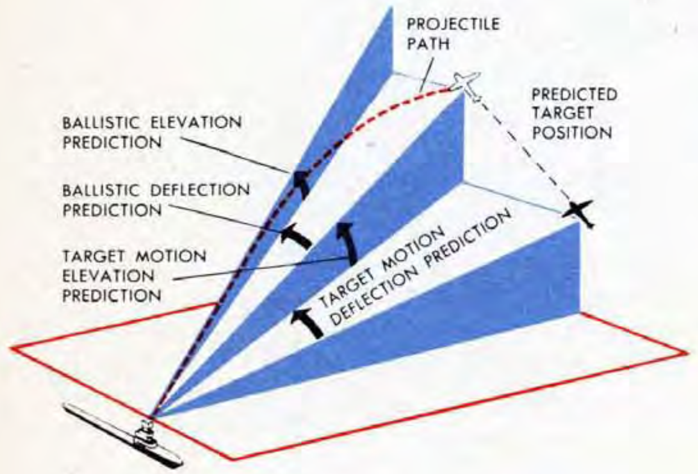


The Prediction Section computes two types of predictions to obtain the Lead Angles:

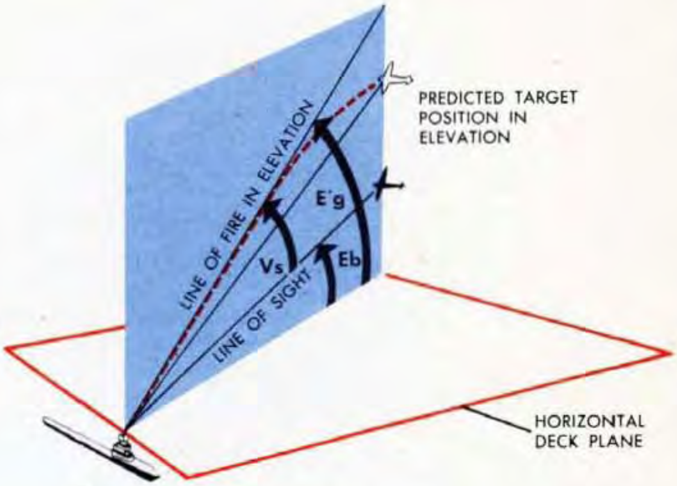
1 Relative Motion Predictions
2 Ballistic Predictions

The Relative Motion Predictions determine the Target's position relative to Own Ship at the end of the Time of Flight by computing Target travel during the time the projectile is on its way. The Prediction Section uses the three Relative Motion Rates and a computed Time of Flight, *Tf*, to obtain the Predicted Target Position in Range, Elevation, and Bearing.

The gun cannot be aimed at this Predicted Target Position because the projectile follows a curved path. The projectile curves downward and over to one side as a result of the combined effects of gravity, drift, wind, and initial velocity. Therefore additional corrections are needed, which are called Ballistic Predictions. The Ballistic Predictions determine the amount the guns must be offset from the Predicted Target Position to allow for the curvature of the projectile path.

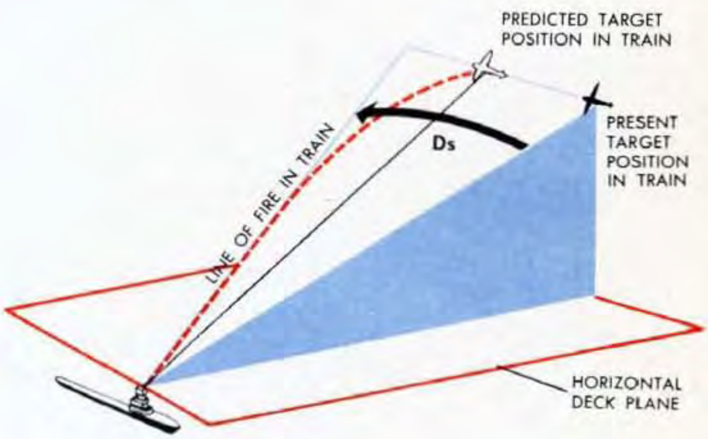


By combining the Relative Motion and Ballistic Predictions, the Prediction Section establishes two Lead Angles which determine a Line of Fire. Projectiles fired along this Predicted Line of Fire will hit the Target at the end of the time of projectile flight.



The Relative Motion Prediction in Elevation combined with the Ballistic Prediction in Elevation gives the Elevation lead angle, called Sight Angle, *Vs.*

On a steady horizontal deck, Sight Angle *Vs,* plus Director Elevation, *Eb,* is the Gun Elevation Order, *E′g.*



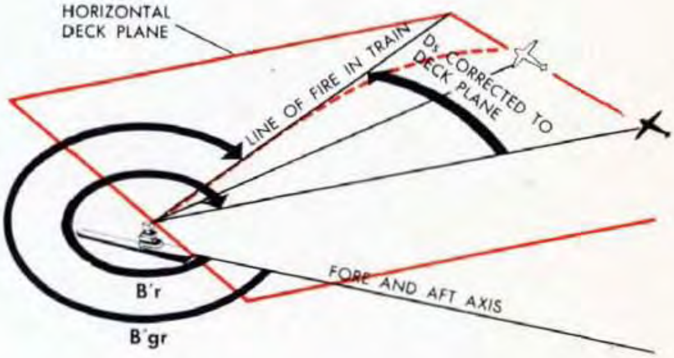
The Relative Motion Prediction in Train combined with the Ballistic Prediction in Train is the Deflection lead angle, called Sight Deflection, *Ds.*

Since *Ds* is computed in a slant plane it must be corrected to the deck plane before it can be used in the Gun Train Order.

On a steady horizontal deck, Gun Train Order, *B′gr,* is made up of Sight Deflection, *Ds,* corrected to the deck plane, plus Director Train, *B′r.*

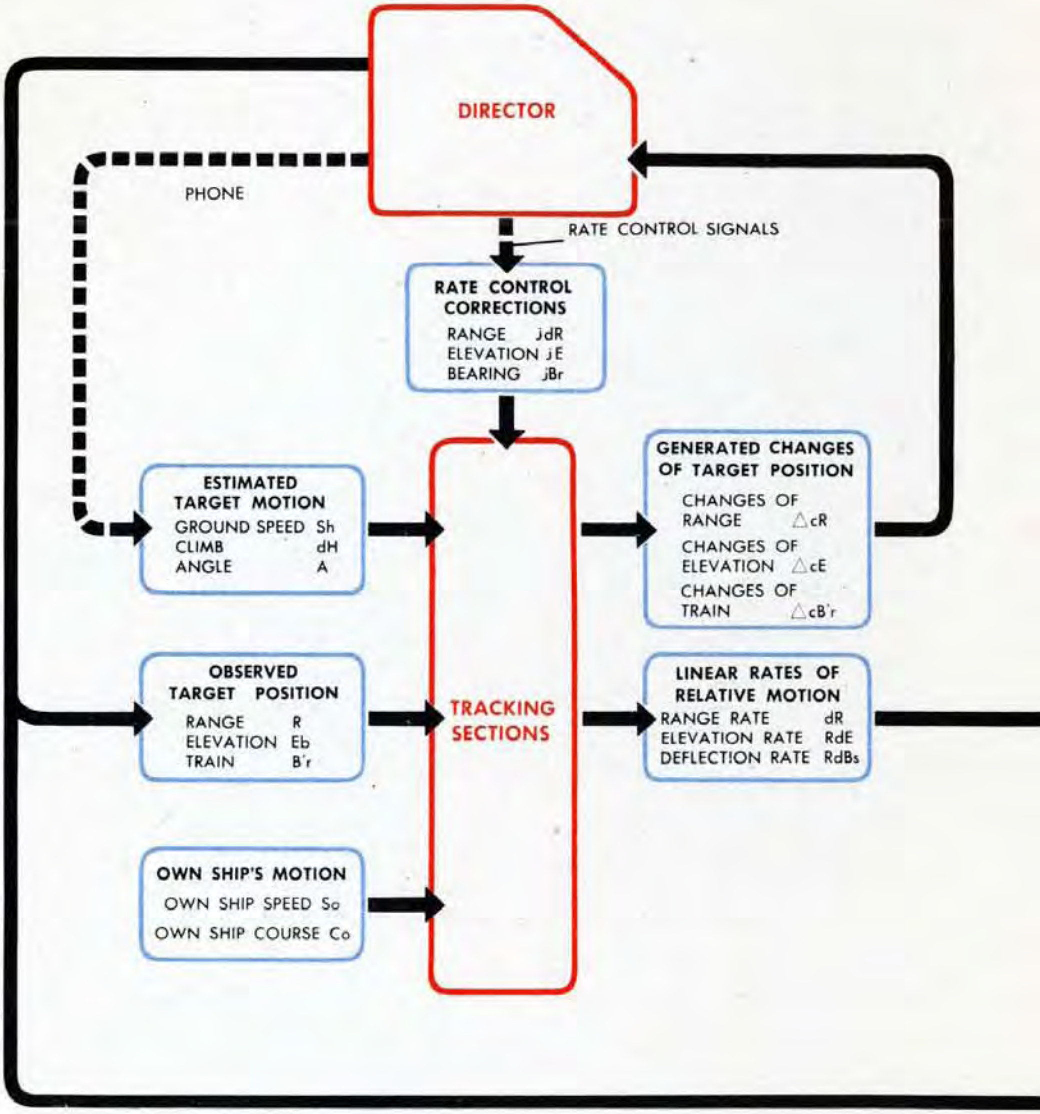
Ds is actually measured in a slant plane somewhat above or below the elevation of the Line of Sight.

The Computer Mark 1 does not compute the Target Motion and Ballistic Predictions separately and add them. Instead, to save mechanisms, it computes them together.

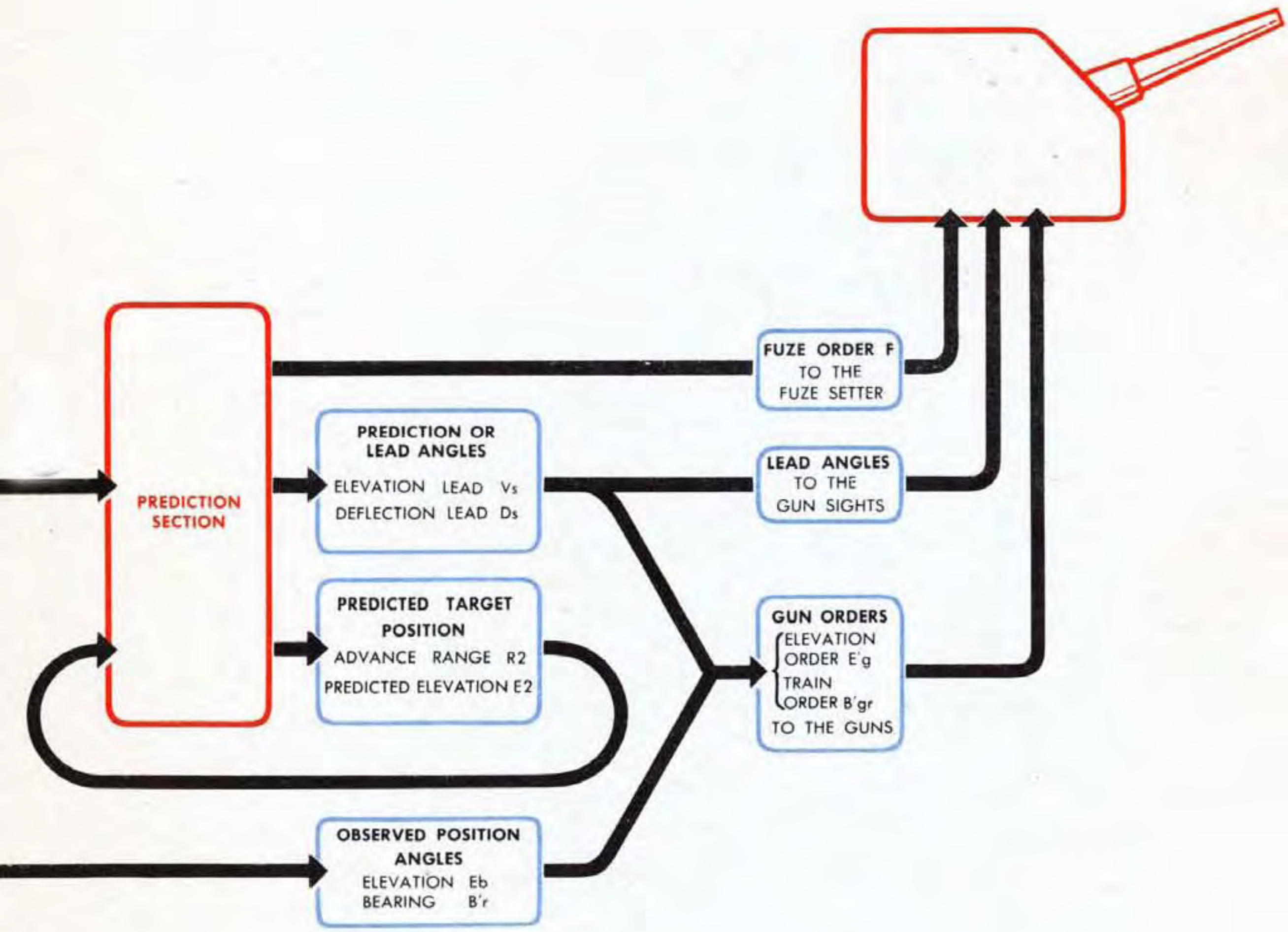


How the sections work together

This schematic shows how the Tracking and Prediction Sections of the Computer are connected to one another and to the Director and guns. Only the sections used in the computation from a horizontal deck are shown in this diagram.



The value of Time of Flight, Tf, which is used in these predictions is the time the projectile will take to reach the Predicted Target Position. Advance Range, $R2$, is approximately the Range to the predicted position of the Target. Predicted Elevation, $E2$, is approximately the Elevation to the predicted position of the Target. To compute a value of Time of Flight, Tf, both $R2$ and $E2$ must be used. After $R2$ and $E2$ have been approximately computed in the Prediction Section, they are used again as INPUTS to this section to compute values of Time of Flight and other ballistic quantities.

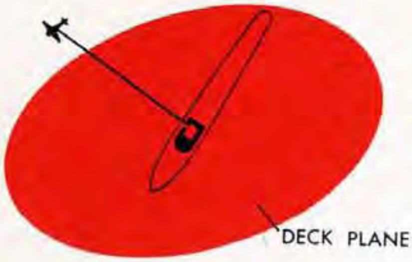


Because they are both outputs from and inputs to the Prediction Section, *R2* and *E2* are called *regenerative* quantities.

R2 and *E2* are quantities used only for computations within the Computer. They are not outputs to the guns or the Fuze Setter.

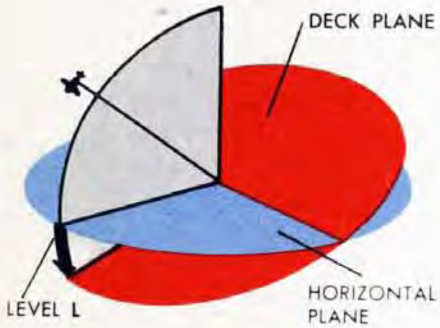
The Fuze Setting Order, *F*, is computed by a ballistic cam in the Prediction Section and is transmitted electrically to the automatic Fuze Setter Indicator Regulator at the gun mounts. Gun Orders are transmitted electrically to the Indicator Regulators in the mounts. The Lead Angles go to the gun sights.

STABILIZATION



So far the Trunnion Tilt Section and the Deck Tilt and Synchronize Elevation Groups have not entered the discussion because the Ship was assumed to be steady and horizontal. Now they must be fitted into the pattern of Computer Mark 1 computations.

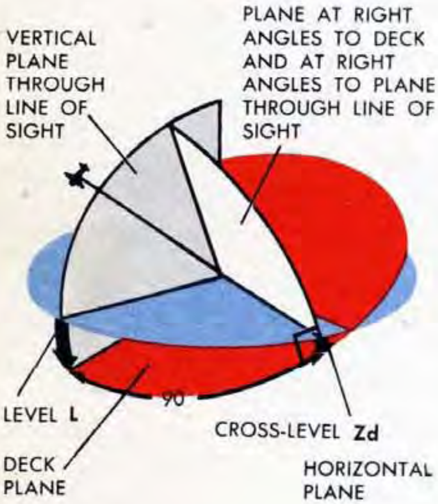
On a pitching and rolling ship there are three main needs for stabilization:



1 The values of Director Elevation and Director Train from the Director must be stabilized, or corrected for the inclination of the deck, before they can be used by the Tracking Section of the Computer. The pitching and rolling of the deck cause the values of Director Elevation and Train to vary, since they are measured from the tilting deck plane. These values have to be referred to the horizontal plane before they can be used for computations, since the Tracking and Prediction Sections of the Computer compute for the horizontal plane.

2 The generated values sent by the Computer to the Director to keep the Director sights on Target must also be corrected to allow for the inclination of the deck.

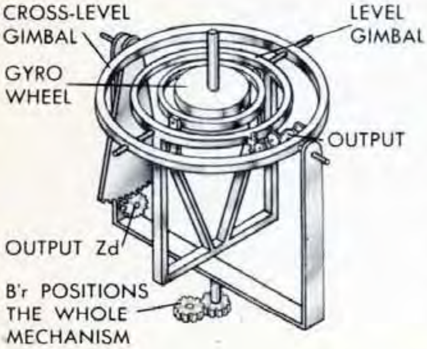
3 The Gun Orders must include corrections to allow for the tilt of the gun trunnions due to inclination of the deck.



The quantities used in stabilizing are Level, *L,* and Cross-Level, *Zd.* These quantities are the measurements of deck inclination in and at right angles to the plane through the Line of Sight.

Level, *L,* is the angle between the deck and the horizontal plane, measured in the vertical plane through the Line of Sight.

Cross-level, *Zd,* is the angle between the deck plane and the horizontal plane measured in a plane at right angles to the vertical plane through the Line of Sight and at right angles to the deck.

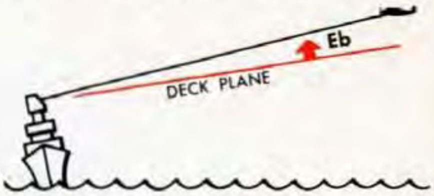


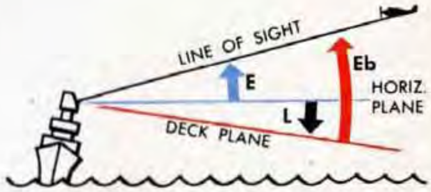
Both Level and Cross-level are measured by the Stable Element. The Stable Element mechanism is positioned by the value of Director Train, *B'r,* from the Computer, so that the Stable Element can always make its measurements in relation to the vertical plane through the Line of Sight.

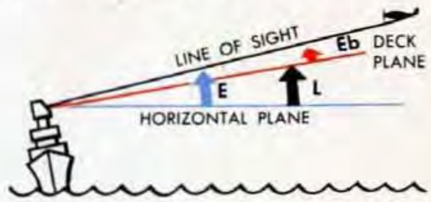
Stabilizing elevation

Since the base of the Director is always parallel to the deck, the whole Director rolls and pitches with the deck, and the measurements made from the Director sights are in or from the deck plane.

Director Elevation, *Eb*, is the elevation of the Line of Sight above the deck. *Eb* is continuously increasing and decreasing as the deck pitches and rolls. For computation, Target Elevation, *E*, above the HORIZONTAL is needed. *E* varies only as the actual elevation of the Target changes. *E* is used in computing Relative Motion Rates, since these rates are computed in relation to the horizontal plane.







To obtain Target Elevation, *E*, the changing value of Level, *L*, is continuously subtracted from Director Elevation, *Eb*. $Eb - L = E$. This subtraction takes place in the Synchronize Elevation Group. *Eb* from the Director and *L* from the Stable Element are the inputs to this group. The output is *E*, which goes to the Relative Motion Group.

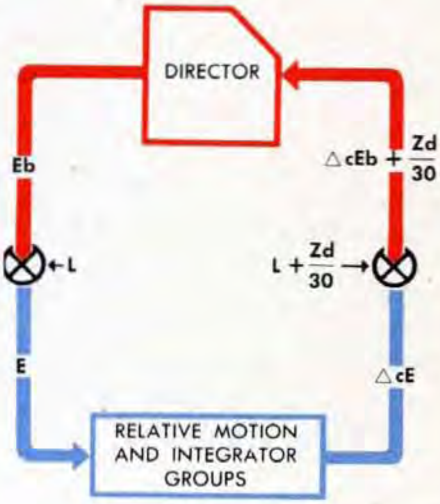
Zd is used to stabilize the Director sights in Cross-level and is always sent directly from the Stable Element to the Director. Therefore, the Director measures *Eb* in the vertical plane through the Line of Sight.

Changes of Target Elevation, $\triangle cE$, are generated by the Integrator Group, using the Linear Elevation Rate, *RdE*, obtained from the Relative Motion Group. $\triangle cE$ positions the Director sights to follow the changing elevation of the Target, but $\triangle cE$ alone cannot keep the sights on Target because of the rolling and pitching of the deck. The value of Level, *L*, which was subtracted from *Eb* to obtain a value of *E* must now be continuously added to $\triangle cE$ to compensate the sights for the motion of the deck. $\triangle cE + L = \triangle cEb$. $\triangle cEb$ is the Generated Changes of Director Elevation.

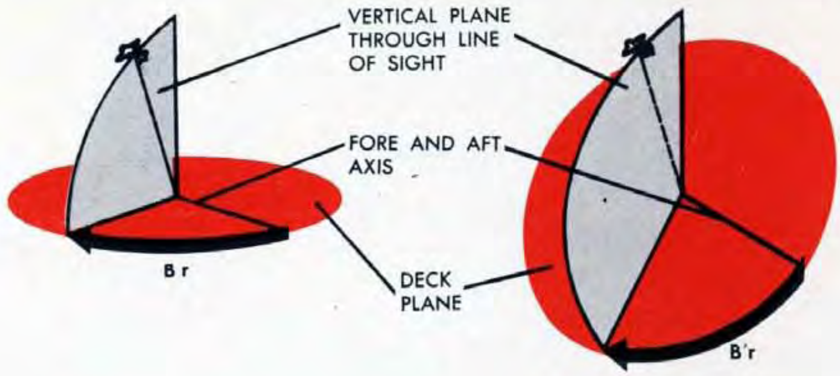
A function of Cross-level, $Zd/30$, is also added. $Zd/30$ permits Cross-level Corrections to be made without affecting Director Elevation.

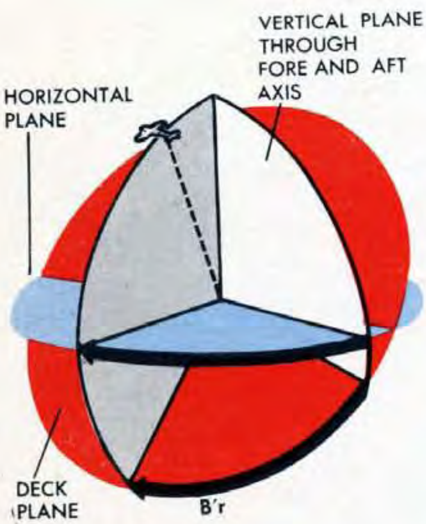
$L + Zd/30$ is usually added to $\triangle cE$ in the Computer and the whole value of $\triangle cEb + Zd/30$ is transmitted to the Director by one transmitter.

In some installations $L + Zd/30$ goes up directly from the Stable Element. $\triangle cE$ goes up alone from the Computer and is added to $L + Zd/30$ in the Director.



Stabilizing relative bearing

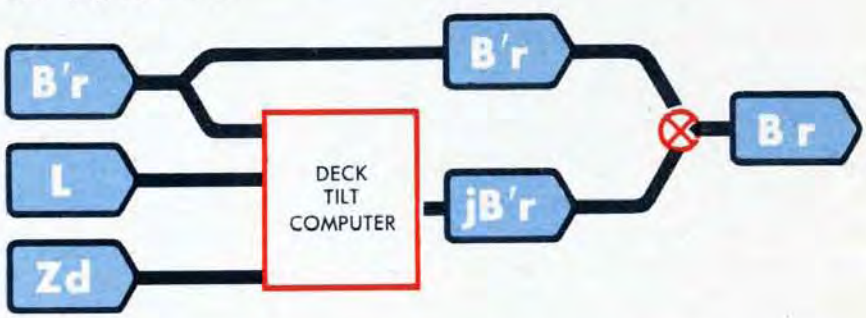


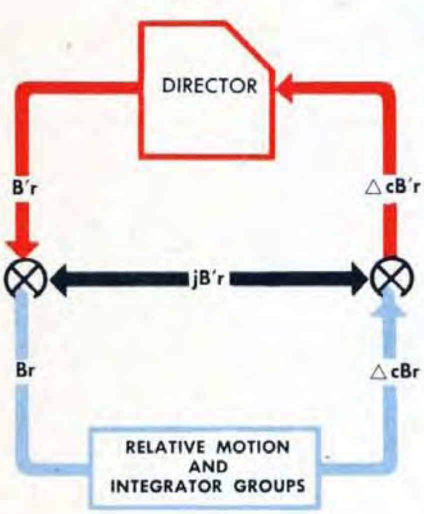


Director Train, $B'r$, is the angle measured in the deck plane from the bow of Own Ship clockwise to the vertical plane of the Line of Sight. When the deck is tilting, the Director must be continuously trained back and forth in order to keep the Line of Sight on the Target. Therefore $B'r$ is continuously increasing and decreasing as the Ship rolls and pitches. This change in $B'r$ due to deck tilt is difficult to visualize. It will be described in detail later in the chapter on Deck Tilt.

For computation in the Tracking Section, the value of Relative Target Bearing in the horizontal plane, Br, is needed. The calculated difference between Br and $B'r$ is a Deck Tilt Correction called $jB'r$. Br is produced by adding $jB'r$ to the measured value of Director Train, $B'r$.

$$B'r + jB'r = Br$$





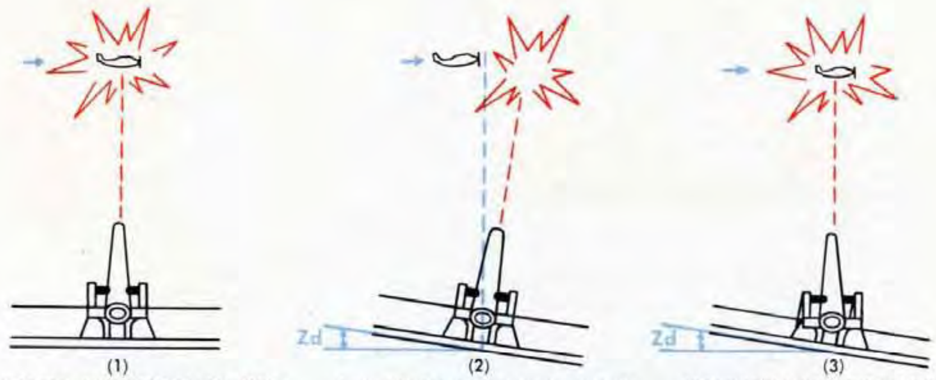
Deck Tilt Correction, $jB'r$, is computed by the Deck Tilt Group. The job of the Deck Tilt Group is to use L, Zd, and $B'r$ to produce this one correction, $jB'r$.

$jB'r$ is also used to convert the Generated Changes of Relative Target Bearing, $\triangle cBr$, computed by the Integrator Group, to Generated Changes of Director Train, $\triangle cB'r$. The Deck Tilt Correction, $jB'r$, is continually subtracted from $\triangle cBr$ to obtain $\triangle cB'r$.

$$\triangle cBr - jB'r = \triangle cB'r$$

$\triangle cB'r$ is the quantity required to keep the Director sights trained on the Target.

Stabilizing the guns



(1)
GUN ORDERS ARE CORRECT SO THAT PROJECTILE BURSTS ON TARGET. GUN TRUNNIONS ARE HORIZONTAL.

(2)
GUN ORDERS HAVE SAME VALUES AS IN (1) BUT TRUNNIONS ARE TILTED. PROJECTILE BURSTS LOW AND TO RIGHT OF TARGET.

(3)
TRUNNIONS ARE TILTED BUT GUN ORDERS ARE CORRECTED BY TRUNNION TILT CORRECTIONS. PROJECTILE BURSTS ON TARGET.

To prevent the guns being thrown off Target by the pitch and roll of the deck, continuous corrections are made to the Gun Orders, in Elevation and in Train.

These corrections are included in the two outputs from the Trunnion Tilt Section, *Vz* and *Dd*.

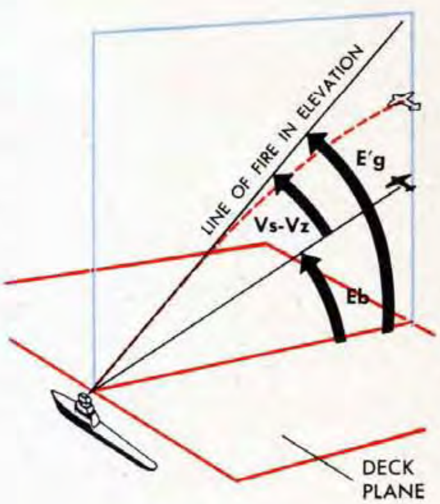
Vz is a correction to gun elevation to offset the tilting of the trunnions. *Vz* is subtracted from Director Elevation, *Eb*, plus Sight Angle, *Vs*, to give Gun Elevation Order, *E'g*.

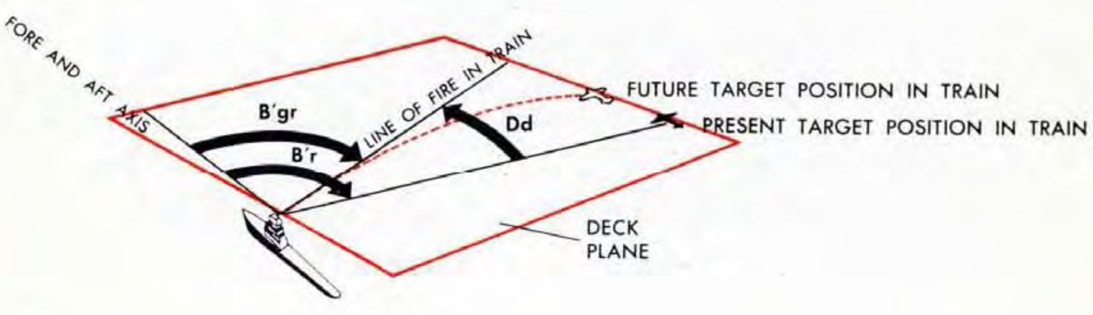
$Eb + Vs - Vz = E'g$

Dd is different from *Vz*. Instead of just correcting the Gun Train Order for Trunnion Tilt, *Dd* includes the whole Deflection Prediction, *Ds*, brought down to the deck plane, plus a train correction for Trunnion Tilt. *Dd* is the total deflection in the deck plane.

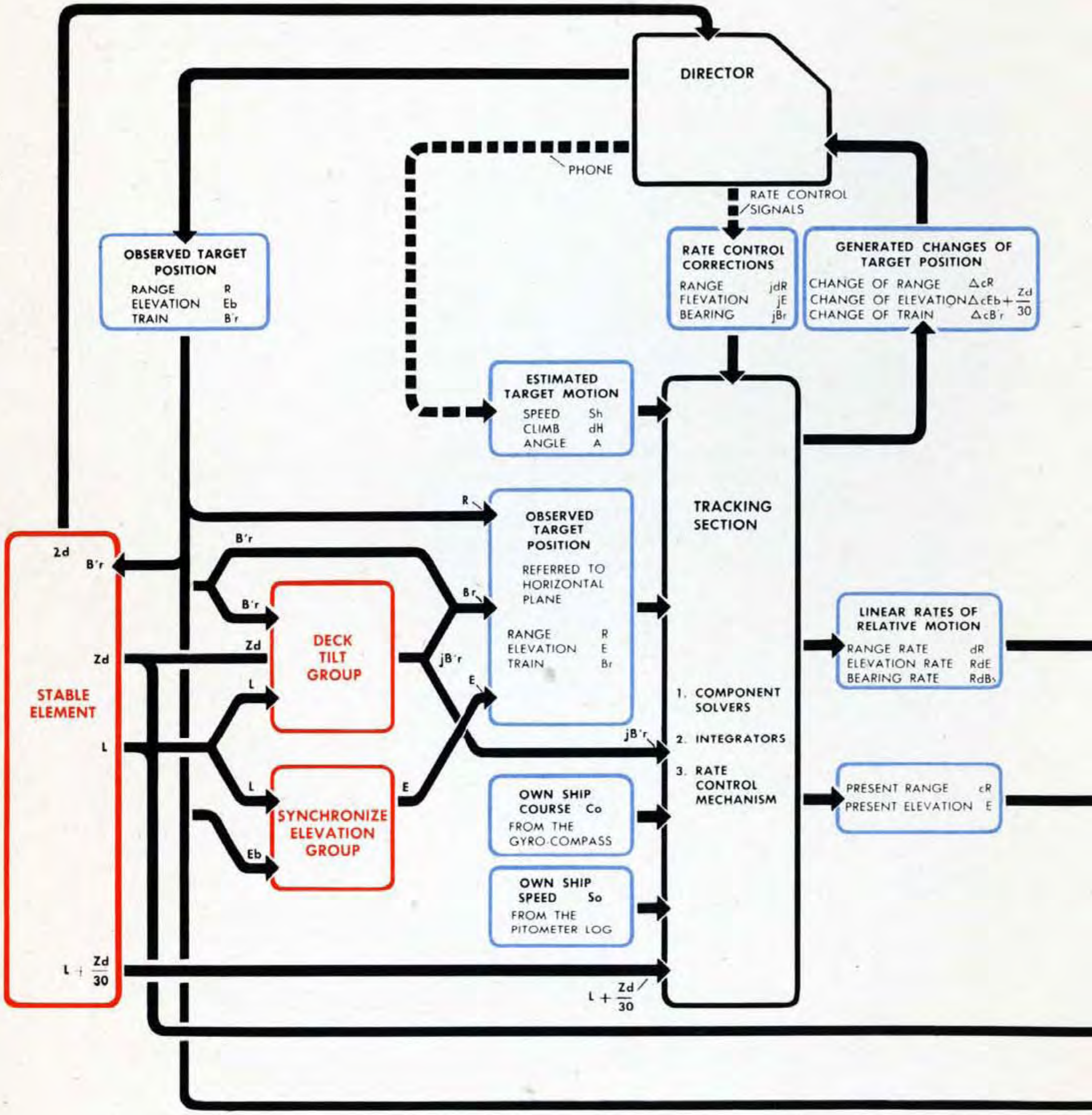
Dd is added directly to Director Train, *B'r*, to obtain Gun Train Order, *B'gr*.

$B'r + Dd = B'gr$

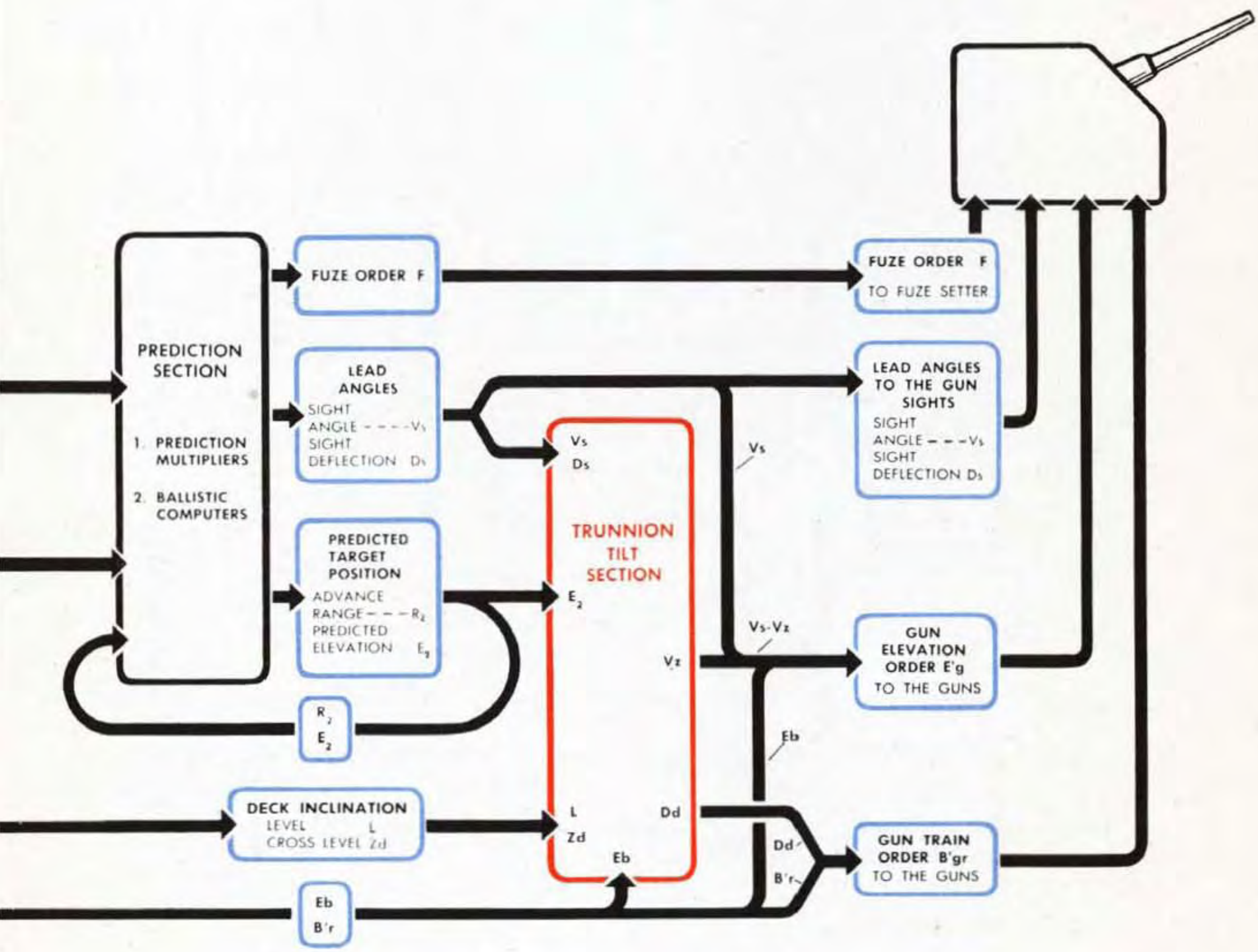




This schematic shows how the stabilizing sections



are connected with the other sections



The tracking cycle for a tilting deck

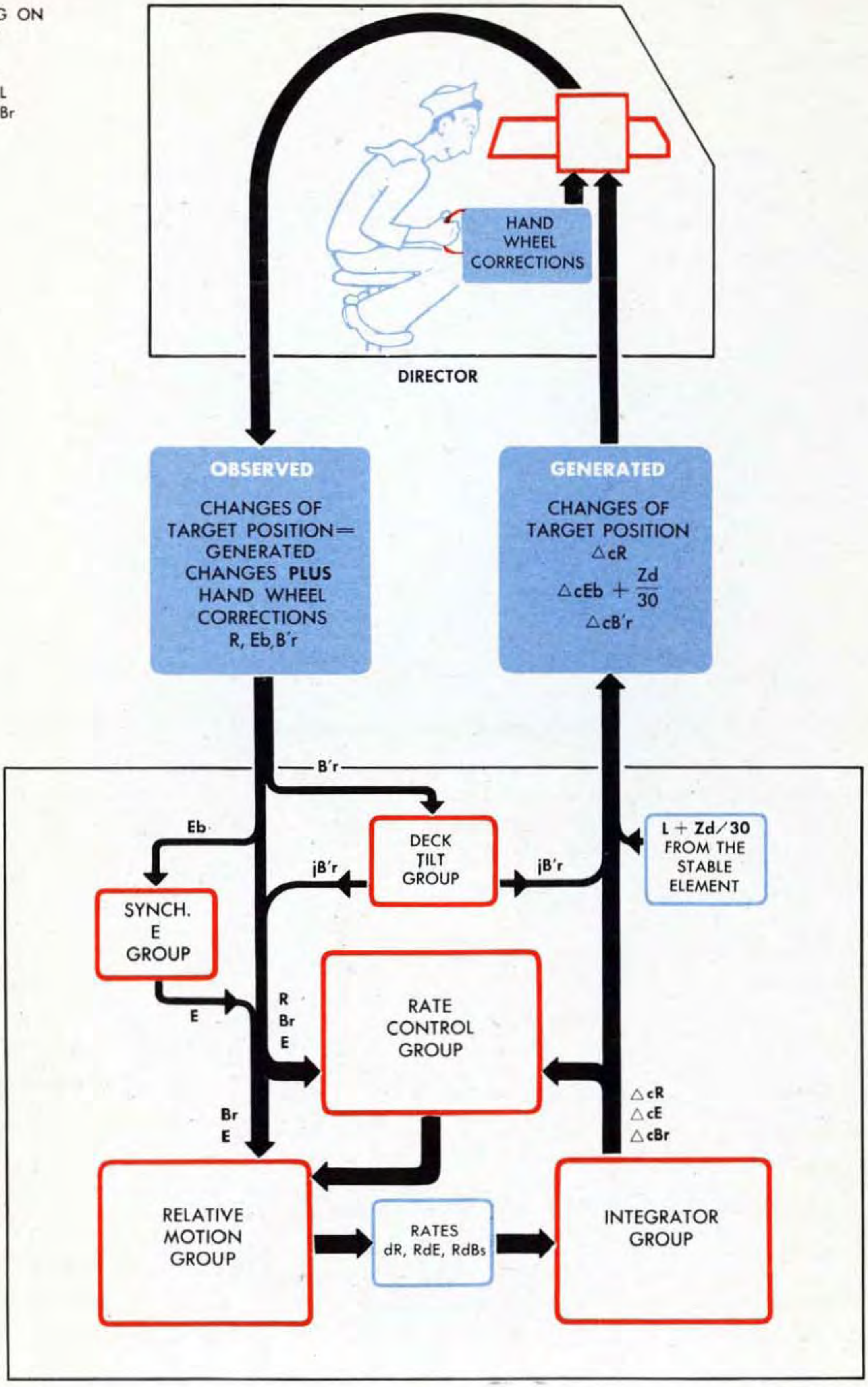
WHEN TRACKING ON A TILTING DECK

$Eb = E + L$

$B'r = Br - jB'r$

$\triangle cEb = \triangle cE + L$

$\triangle cB'r = \triangle cBr - jBr$

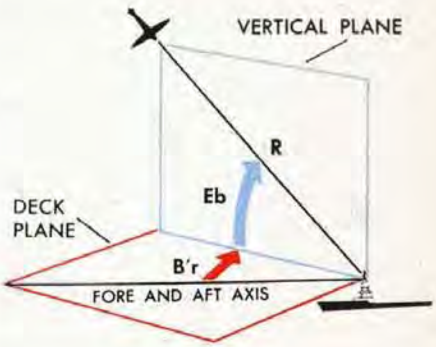


A MORE DETAILED ACCOUNT OF TRACKING, PREDICTION, AND STABILIZATION

In the simplified account of tracking, prediction, and stabilization, the mechanisms were handled in groups and only the quantities comprising the inputs and outputs of the sections and groups were discussed.

In the more detailed account which follows, each mechanism is shown separately and most of the intermediate quantities computed inside the sections are introduced.

The quantities not covered in this account are included in the Detailed Description of the Computer Mark 1 in Part 3 of this OP.



The inputs to the tracking section

When a target is sighted, the Director Crew puts the telescopes and Range Finder on it, and the values of Range, *R,* Director Train in the deck plane, *B'r,* and Director Elevation above the deck plane, *Eb,* are transmitted automatically to the Computer.

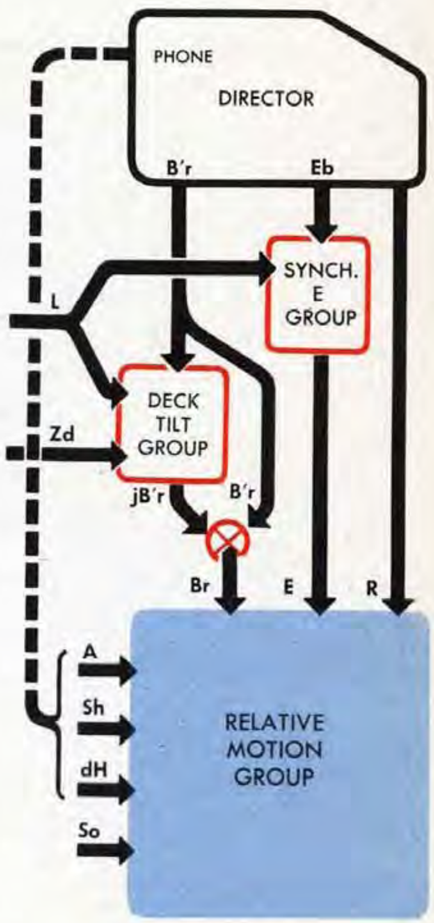
Observed Range, *R,* goes to the Range Receiver in the Rate Control Group and will be discussed later.

Director Train, *B'r,* is transmitted to the *B'r* Receiver in the Computer. Director Train is needed in the Relative Motion Group, but first it must be converted to the horizontal plane. *B'r* therefore goes from the *B'r* Receiver to the Deck Tilt Group.

In the Deck Tilt Group, *B'r, L,* and *Zd* are used to compute the Deck Tilt Correction, *jB'r.* The Deck Tilt Group consists of a component solver and two multipliers. These three mechanisms are needed to produce the one output, *jB'r,* which is added to *B'r* to obtain *Br,* Relative Target Bearing in the horizontal plane.

Br then goes to the Relative Motion Group.

Eb from the Director goes to the *Eb* Receiver in the Computer, and from there to the Synchronize Elevation Group, where *L* is subtracted from *Eb,* giving *E.* The Synchronize Elevation Group, which consists of an arrangement of differentials and brakes, sends the value *E* to the Relative Motion Group, and also to other sections of the Computer.

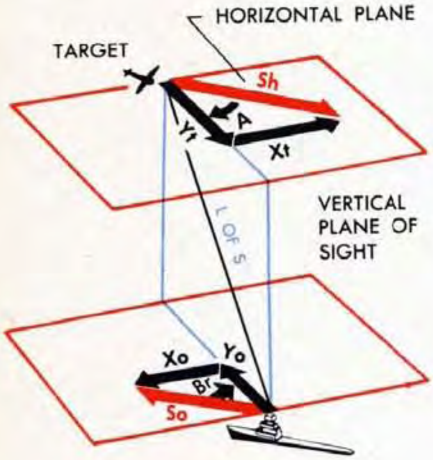


The values of Target Speed, *Sh,* Target Course, *Ct,* and Rate of Climb, *dH,* are estimated by the Control Officer in the Director, phoned down to the plotting room and cranked into the Relative Motion Group as *Sh, A,* and *dH.*

The remaining inputs to the Tracking Section are Ship Speed, *So,* and Ship Course, *Co.* *So* is transmitted electrically from the Pitometer Log to the *So* Receiver in the Relative Motion Group. *Co* is transmitted electrically from the Gyro Compass to the *Co* Receiver.

Computing RELATIVE MOTION rates

The Relative Motion Group contains a bank of four component solvers.

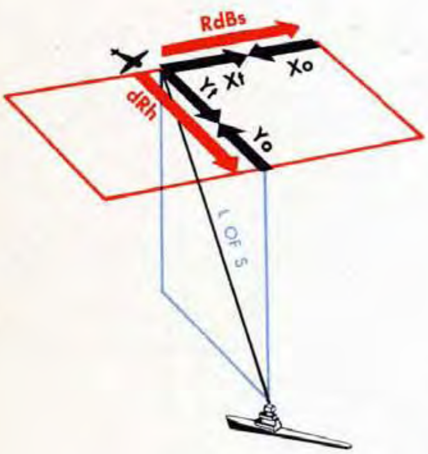


The Ship Component Solver takes Ship Speed, *So*, and Relative Bearing, *Br*, and computes the horizontal components of Ship Motion in and at right angles to the plane of sight.

The components are called *Xo* and *Yo*.

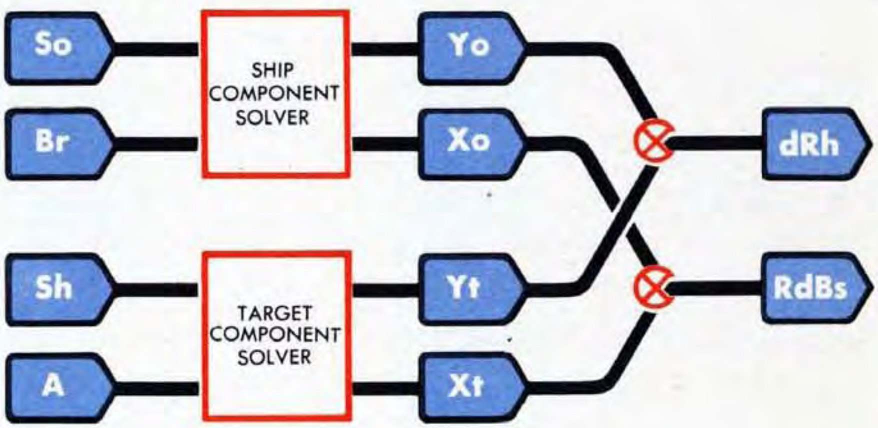
The Target Component Solver breaks down Target Speed, *Sh*, using Target Angle, *A*.

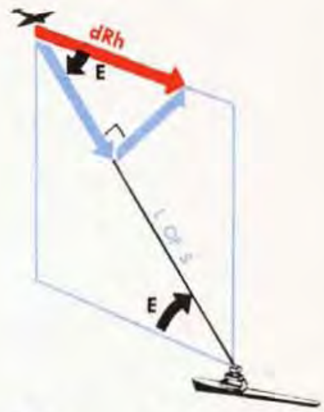
The Target Motion components are called *Xt* and *Yt*.



The Component of Ship Motion, *Yo*, is added to the Component of Target Motion, *Yt*, to give the linear Horizontal Range Rate, *dRh*. *dRh* is the combined motion of Ship and Target along a horizontal projection of the Line of Sight.

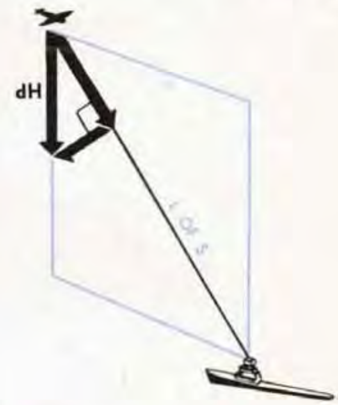
The two horizontal components, *Xo* and *Xt*, at right angles to the vertical plane through the Line of Sight are added to give total linear Deflection Rate, *RdBs*.





Direct Range Rate, *dR*, and Linear Elevation Rate, *RdE*, are computed from components of Horizontal Range Rate, *dRh*, and Rate of Climb, *dH*.

dRh and Target Elevation, *E*, go into the *dRh* Component Solver. The outputs of this solver are the components of *dRh* along and at right angles to the Line of Sight in the vertical plane through the Line of Sight.

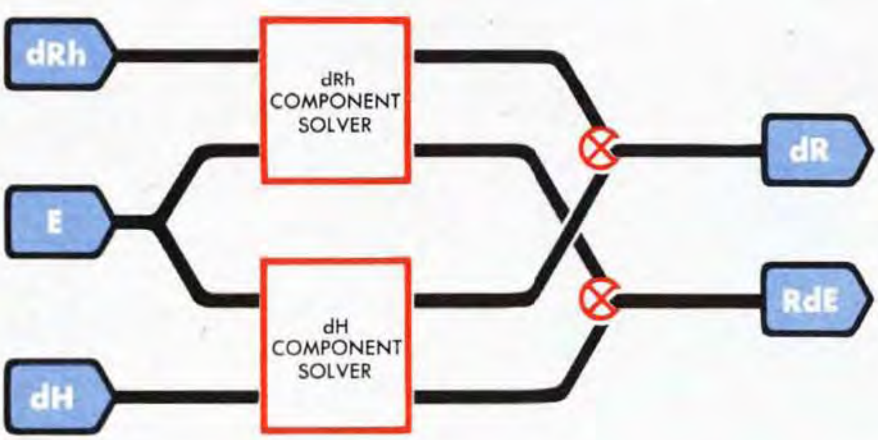


The *dH* Component Solver breaks up *dH* and angle *E* into components, also along and at right angles to the Line of Sight in the vertical plane through the Line of Sight.

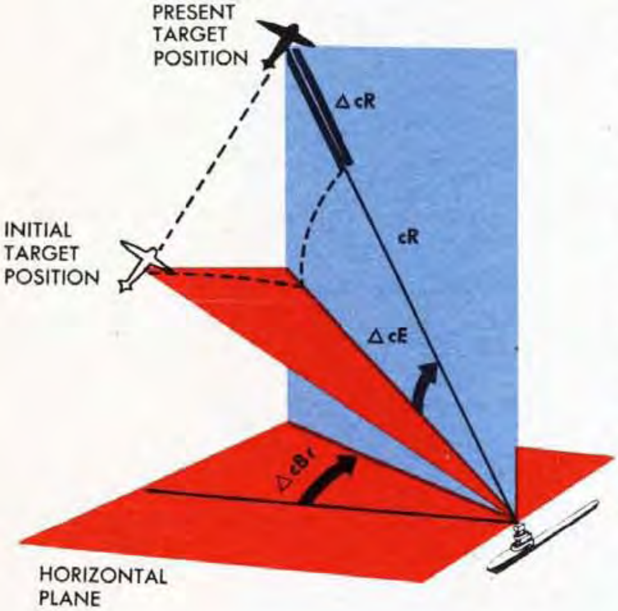
The components from each of these solvers lying along the Line of Sight are then added to give Direct Range Rate, *dR*. Direct Range Rate, *dR*, is the rate at which the Ship and Target are approaching or going apart from each other along the Line of Sight. It is the rate at which the Range is changing.

The two components at right angles to the Line of Sight make up Linear Elevation Rate, *RdE*, the combined Ship and Target speed at right angles to the Line of Sight in the vertical plane.

The Relative Motion Group computes these three Relative Motion Rates: *dR*, *RdE*, and *RdBs*.



THE INTEGRATOR GROUP



The Integrator Group has the job of generating continuous changes of Target Position. It computes Generated Changes of Range, $\triangle cR$, to drive the Generated Range Dials in the Computer and the Range Finder in the Director.

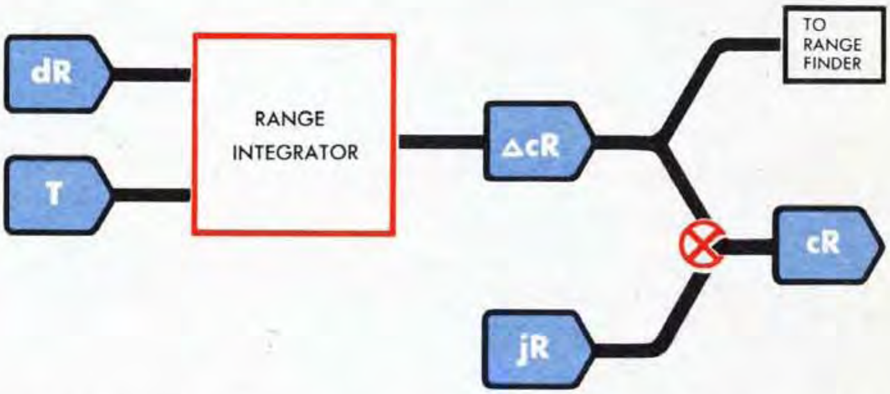
To drive the Generated Elevation and Bearing Dials the Integrator Group computes the Generated Changes of Target Elevation, $\triangle cE$, and Generated Changes of Relative Target Bearing, $\triangle cBr$.

To position the Director sights the Group also computes Generated Changes of Director Elevation, $\triangle cEb + Zd/30$, and Generated Changes of Director Train, $\triangle cB'r$.

The Integrator Group contains five disk integrators and two computing cam units.

Generating changes of range

The calculation of Range changes is fairly simple and is explained in detail in OP 1140.



The Range Integrator continuously multiplies the Range Rate, dR, by Time, T, to produce a continuous flow of increases or decreases in Range during the periods of Time, T. These changes in Range, $\triangle cR$, are continuously added to the Initial Range Setting, jR, to produce the Present Generated Range, cR, at any moment.

$\triangle cR$ positions the Range Finder in the Director.

Generating changes of elevation

Generating changes of Elevation and Bearing is a little more complicated than generating changes of Range, because the changes of Elevation and Bearing are ANGULAR changes. They are the changes that the sights must make in Elevation and Train to stay on the Target.

The Generated Changes of Elevation, $\triangle cE$, are calculated as follows:

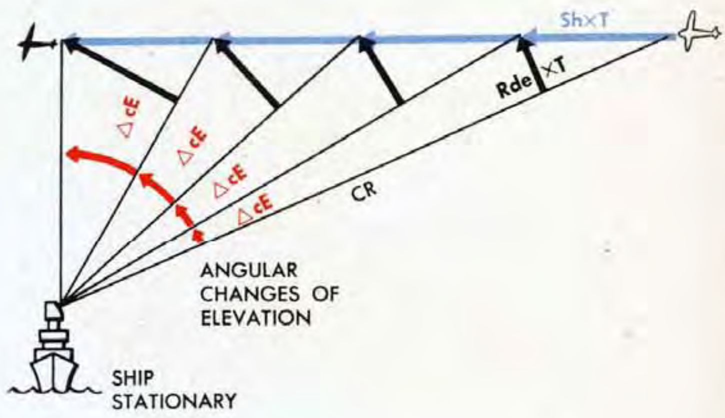
Elevation Rate, *RdE*, multiplied by Time, *T*, gives the linear Elevation change during the Time, *T*. $RdE \times T$ divided by the Range, *cR*, gives angular change in Elevation in radians.

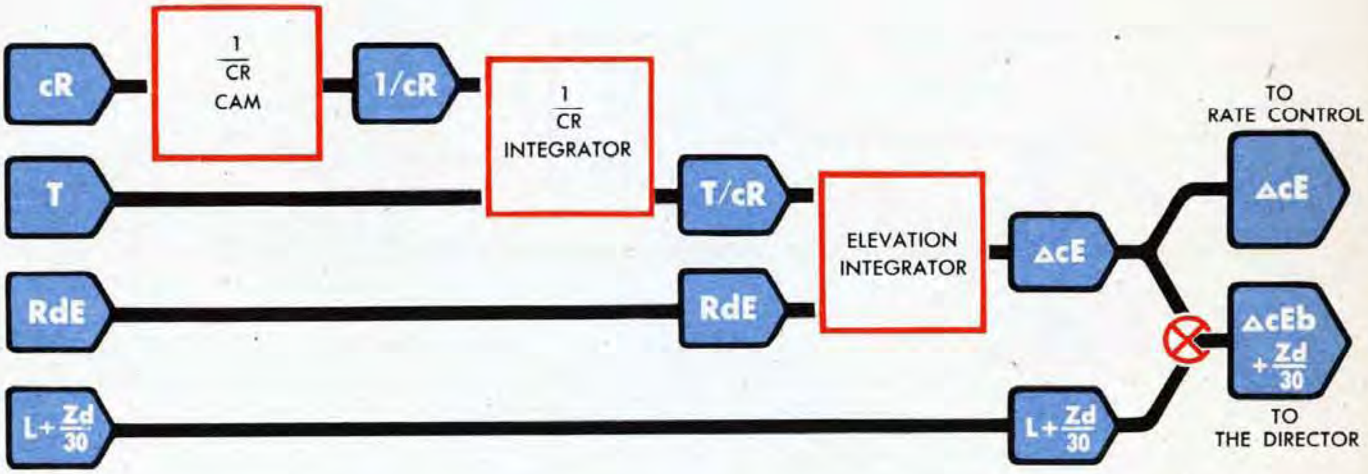
The Generated Angular Elevation Change, $\triangle cE$, is therefore computed for each successive instant of Time as $RdE \times T/cR$

$\triangle cE$ is computed in three mechanisms.

A reciprocal cam computes continuous values of $1/cR$. The changing values of $1/cR$ are multiplied by Time, *T*, in the $1/cR$ Integrator to give continuous values of T/cR. Then the values of T/cR are multiplied by the Elevation Rate, *RdE*, in the Elevation Integrator, to give continuous values of $RdE \times T/cR$, which are the Generated Changes of Elevation, $\triangle cE$.

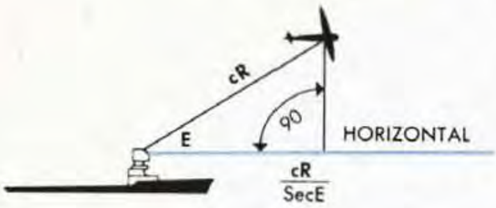
$\triangle cE$ continuously positions the Generated Elevation Dials in the Rate Control Group.



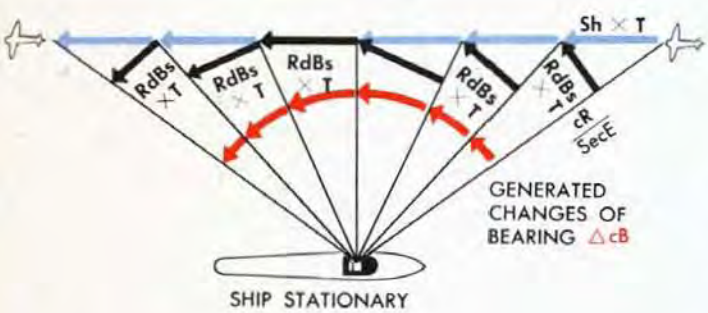


$L + Zd/30$ is added to $\triangle cE$, giving $\triangle cEb + Zd/30$. $\triangle cEb + Zd/30$ is continuously transmitted to the Director sights. The value of *L* compensates the sights for the effect of Level. The value $Zd/30$ permits Cross-level Corrections to be made at the Director without affecting Director Elevation.

Generating changes of director train



Computing the Generated Changes of Director Train requires more mechanisms than computing Generated Changes of Elevation. These Director Train increments must not only be ANGULAR increments but they must also be converted to the deck plane. Since the Director trains in the deck plane, Generated Changes of True Bearing in the horizontal plane, $\triangle cB$, are computed and then converted, first to Generated Changes of Relative Bearing, $\triangle cBr$, and then to Generated Changes of Director Train, $\triangle cB'r$.

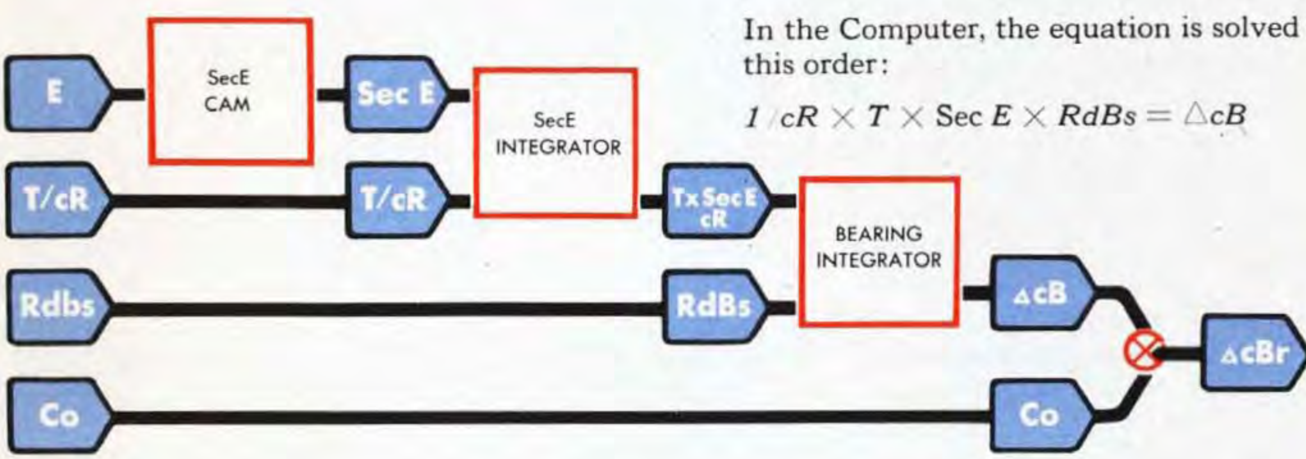


The Generated Angular Changes of True Bearing in the horizontal plane, $\triangle cB$, are computed like $\triangle cE$ except that $cR/\text{Sec } E$ is used instead of cR. This is necessary to convert from the slant plane of the Line of Sight to the horizontal plane.

$$\triangle cB = \frac{RdBs \times T}{\text{Horizontal Range}} = \frac{RdBs \times T}{cR/\text{Sec } E} = \frac{RdBs \times T \times \text{Sec } E}{cR}$$

In the Computer, the equation is solved in this order:

$1/cR \times T \times \text{Sec } E \times RdBs = \triangle cB$

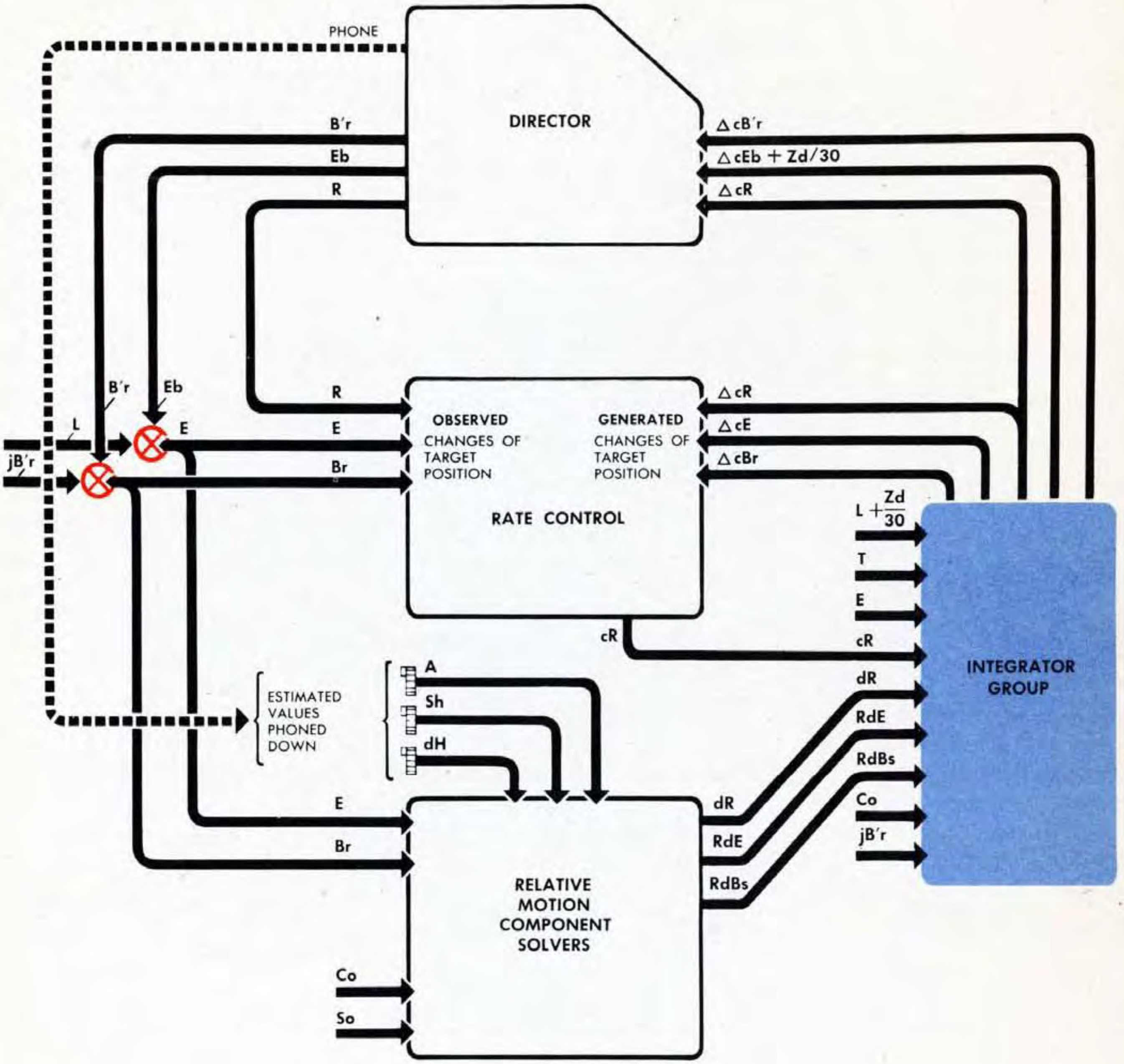


Own Ship Course, Co, is subtracted from $\triangle cB$ to take out the effect of a change in Own Ship Course. The new quantity obtained is the Generated Changes of Relative Bearing in the horizontal plane, $\triangle cBr$.

$\triangle cB - Co = \triangle cBr$

Deck Tilt Correction, $jB'r$, is subtracted from $\triangle cBr$ to correct it for the effect of deck inclination. The new quantity is the Generated Changes of Director Train, $\triangle cB'r$. $\triangle cB'r$ keeps the Director sights on Target in train regardless of changes in Own Ship Course and deck inclination.

Here are all the inputs and outputs of the integrator group



The RATE CONTROL GROUP

The function of the Rate Control Group is to correct the estimated values of *Sh, dH*, and *A*.

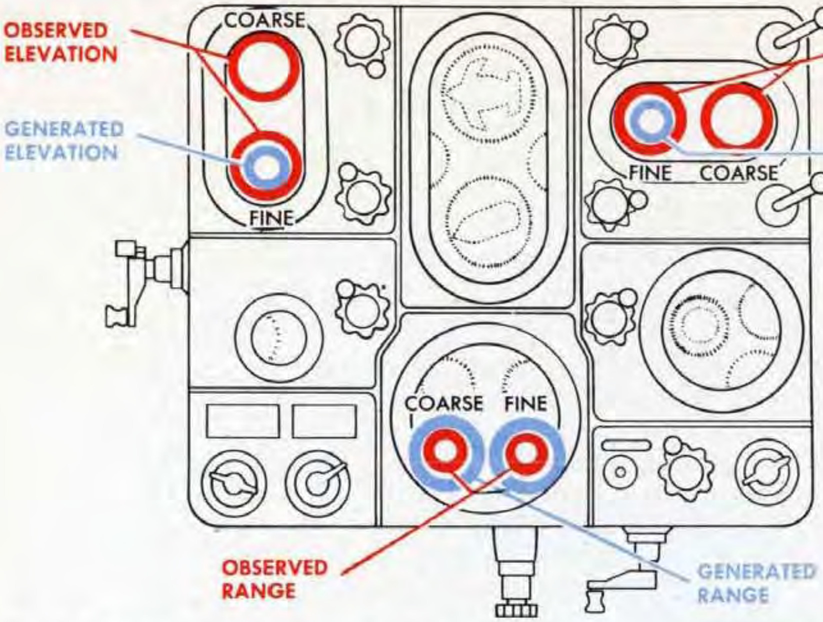
All the values needed by the Computer in tracking and in computing Gun Orders are available, except the values of Target Speed, Target Angle, and Rate of Climb. Target Position can be continuously measured; Own Ship Speed and Course are known; wind, deck inclination, and all the other necessary quantities can be measured. But Target Motion has to be *estimated*.

Even a very experienced man cannot make accurate estimates at long ranges, and the estimates, therefore, always have to be checked and corrected.

The Relative Motion Rates are computed from known values of Own Ship Motion, known values of Target Position, and *estimates* of Target Motion. When the Target Motion estimates are correct, the Relative Motion *Rates* will also be correct. The process of correcting Target Speed, Target Angle and Rate of Climb is therefore called *"Rate Control."*

The method of correcting the Target Motion estimates is this: First the Relative Motion Group computes Relative Motion Rates based on the estimates. Then the Integrator Group uses these rates to generate continuous changes of Target Position. These generated changes are compared with observed changes, and the differences between generated and observed changes are used to correct the estimates.

The job of the Rate Control Computing Mechanism is to analyze the differences between Observed Range and Generated Range, between Observed Elevation and Generated Elevation, and between Observed Target Bearing and Generated Target Bearing, to determine what errors in Target Speed, *Sh*, Target Angle, *A*, and Rate of Climb, *dH*, were responsible for the differences, and to correct these errors.



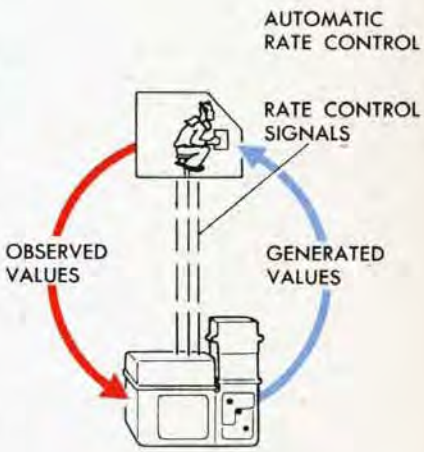
Both GENERATED and OBSERVED changes of Range, Bearing and Elevation show on dials on the top front section of the Computer Mark 1.

In Elevation and Bearing, the outer dials, fine and coarse, are positioned by the observed quantities in the horizontal plane, *E* and *Br*. The inner fine dials are positioned by the generated values, $\triangle cE$ and $\triangle cBr$.

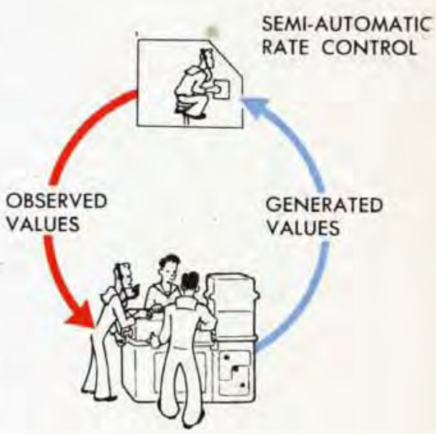
In Range the dials are arranged in the opposite way. The INNER dials are positioned by Observed Range, *R*, the outer dials by Generated Range, *cR*.

The Rate Control Group consists of the Range, Elevation, and Bearing Dials, a system of locks, clutches, and follow-ups, and the Rate Control Computing Mechanism. The Rate Control Computing Mechanism consists of four component integrators and a vector solver.

There are several ways of rate-controlling. The two methods which make use of the Rate Control Computing Mechanism are Automatic and Semi-automatic Rate Control.



In Automatic Rate Control, corrections are put into the Rate Control Computing Mechanism automatically on signals from the Director.



In Semi-automatic Rate Control, corrections are put into the Rate Control Computing Mechanism by handcranks at the Computer.

AUTOMATIC and SEMI-AUTOMATIC RATE CONTROL

Since Elevation and Bearing Rate Control are identical, and Range Rate Control is similar to these two, an error in just ONE of these quantities will serve to show how a Rate Control correction is put into the Rate Control Computing Mechanism.

Suppose the sights begin to move off in elevation. The Pointer turns his handwheels to bring them on. By turning his handwheels, he changes the value of Observed Elevation, *E*, in the Computer. The introduction of this change throws the Observed and Generated Dials out of synchronism.

What happens after this depends on the type of operation being used.

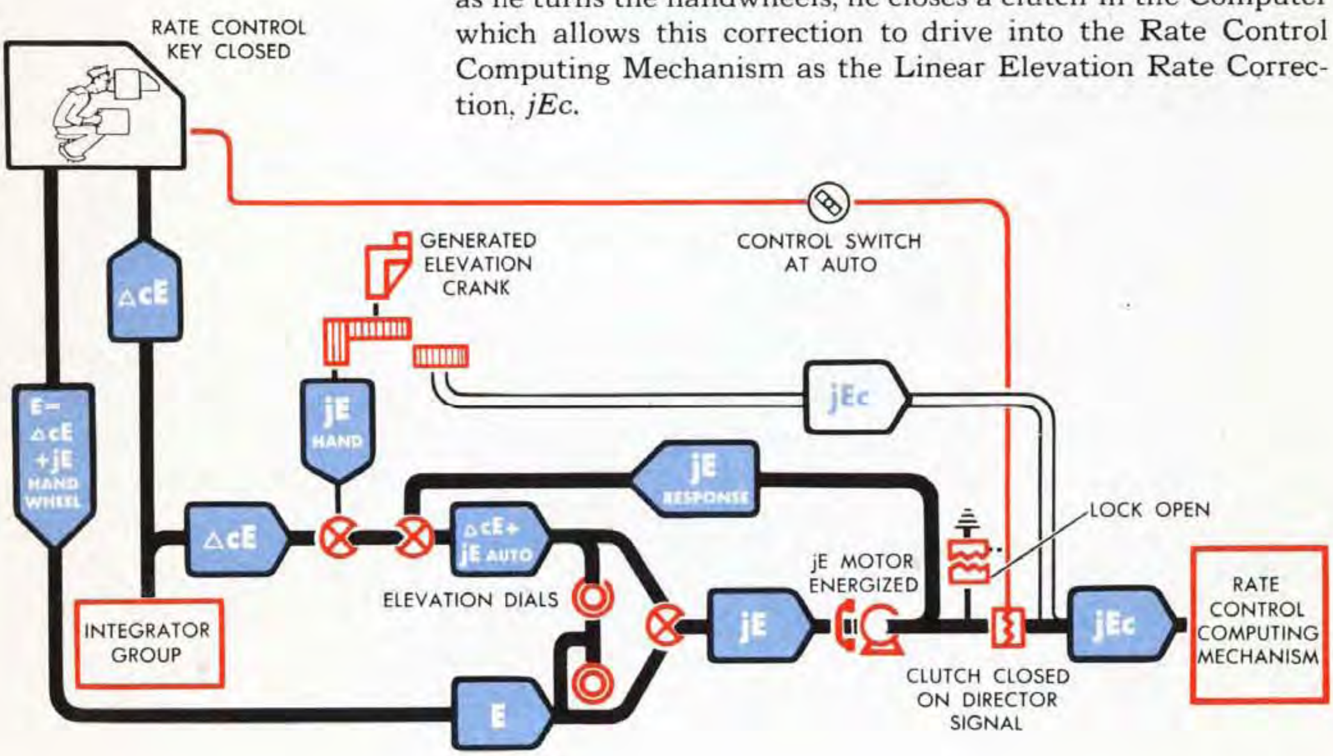
In Automatic Operation, the Generated and Observed Changes of Elevation are continuously fed into a differential which compares them.

As long as the Generated Changes equal the Observed Changes, the output of the differential is at zero.

When the Pointer turns his handwheels, making a change in Observed Elevation, the two sides of the differential no longer match. The difference between the two sides, *jE*, controls a follow-up motor which drives the Generated Elevation line until it matches the value on the Observed Elevation line.

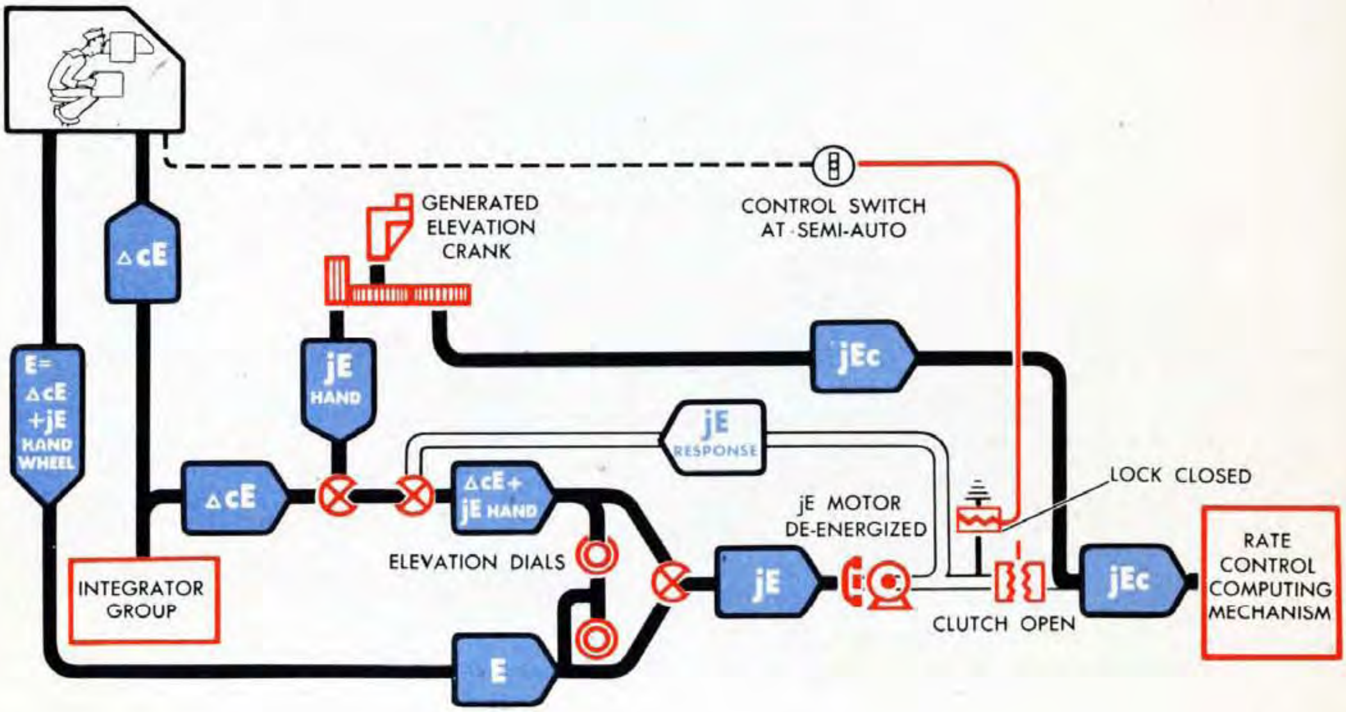
The amount the follow-up drives represents the Angular Correction in Elevation, *jE*.

If the Pointer in the Director has his Rate Control Key closed as he turns the handwheels, he closes a clutch in the Computer which allows this correction to drive into the Rate Control Computing Mechanism as the Linear Elevation Rate Correction, *jEc*.



In Semi-automatic Operation, the Pointer in the Director does not control the Elevation Rate Correction input line to the Rate Control Computing Mechanism. This line is controlled by the Elevation Operator at the Computer. The Elevation Operator watches the Elevation Dials, and as soon as he sees that the Generated Elevation Dial is turning faster or slower than the Observed Elevation Dial, he turns the Generated Elevation Crank in its IN position until the dials turn together. By turning the crank in the IN position he is not only matching the Elevation Dials but is also putting Elevation Rate Correction, *jEc*, into the Rate Control Computing Mechanism.

NOTE: In describing Rate Control, the quantities coming from and going to the Director have been referred to the horizontal plane. The stabilizing quantities, *L* and *Zd/30*, have been omitted.



Putting in range rate control corrections

Deflection Rate Control Corrections are put into the Rate Control Computing Mechanism in exactly the same way as Elevation Rate Control Corrections.

Range Rate Control Corrections are put in a little differently. All Elevation and Bearing lines in the Computer are driven by OBSERVED Elevation and Bearing, but the Range lines in the Computer are driven by GENERATED Range. The reason for this is that while Elevation and Bearing can be measured continuously, the Range Finder can only be focused intermittently. Generated Range is therefore a more smoothly and continuously changing quantity than Observed Range.

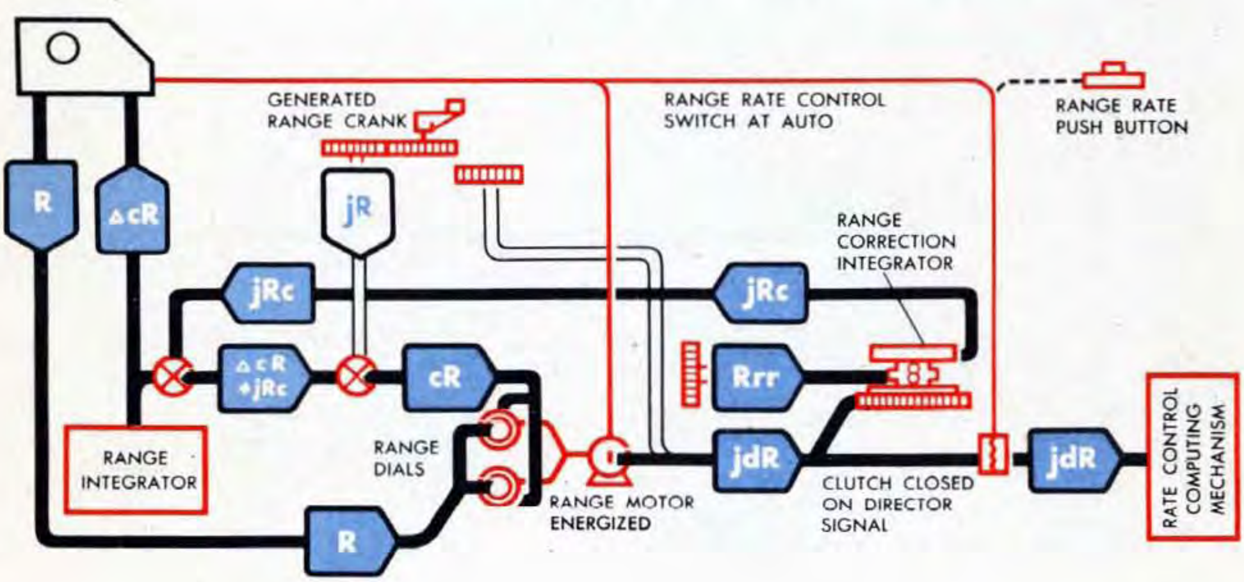
Because it positions all the Range lines, *cR* has to be very accurate. Generated Elevation and Bearing must change at the same rates as Observed Elevation and Bearing. *cR* must not only change at the same rate as *R*, *but also must be exactly equal to R whenever R is correct.*

When Generated Range, *cR*, changes at a different rate from Observed Range, *R*, Range Rate Control is needed.

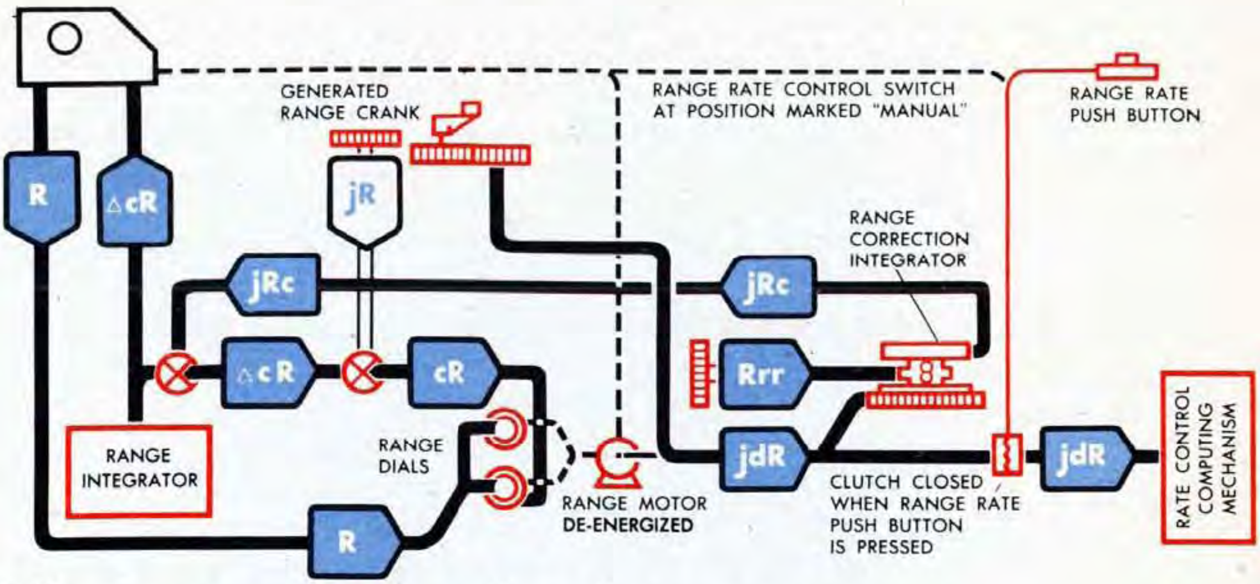
Range Rate Corrections going into the Rate Control Computing Mechanism are controlled through a mechanism called the Range Correction Integrator.

In Automatic Operation, *R* and *cR* are compared at the Range Dials. A special contact arrangement between the dials controls a motor which drives the difference between *R* and *cR* through the Range Correction Integrator into the *cR* line whenever the Signal Key in the Director is closed. This linear correction to *cR* is called *jRc*.

On the same signal from the Range Operator in the Director, a value proportional to the difference between *R* and *cR* is also driven through a clutch into the Rate Control Computing Mechanism, as Range Rate Correction, *jdR*.



In Semi-automatic Operation both the Linear Range Correction, *jRc*, and the Range Rate Correction, *jdR*, are put in manually by the Generated Range Crank in its IN position. The clutch through which *jdR* goes to the Rate Control Computing Mechanism is controlled by the Range Rate Manual Push-button.



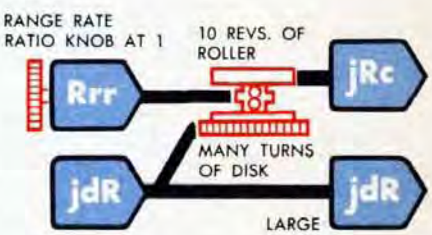
The range correction integrator

The function of the Range Correction Integrator is to control the amount of Range Rate Correction going into the Rate Control Computing Mechanism for any given amount of linear Range Correction.

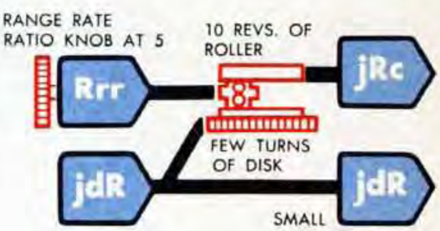
The disk of the Range Rate Integrator is turned by Range Rate Correction, *jdR*. The carriage is positioned directly by the Range Rate Ratio Knob on the front of the Computer. The roller drives Linear Range Correction, *jRc*, into the Generated Range Line.

The Range Rate Ratio Knob has a drum numbered from 1 to 5. The setting of this knob determines the amount of Range Rate Correction introduced for each linear correction to Generated Range.

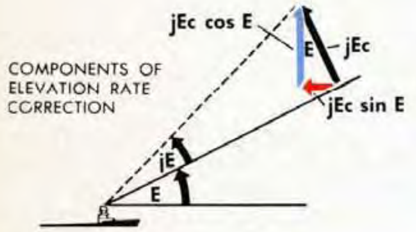
Suppose Generated Range needs a correction *jRc* which requires ten turns of the integrator roller. If the Range Rate Ratio Knob is at 1, a relatively large Range Rate Correction, *jdR*, goes into the Rate Control Computing Mechanism for each Range Correction, *jRc*, because the integrator carriage is positioned near the center of the disk. With the carriage near the center, relatively many turns of the disk are needed to turn the roller ten revolutions. A relatively large *jdR* is therefore put in for the *jRc* needed to match the Range Dials.

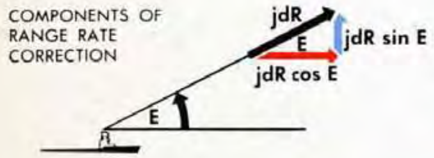


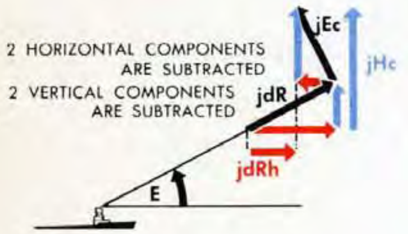
With the Range Rate Ratio Knob positioned near 5, a small Range Rate Correction, *jdR*, goes in for each Range Correction, *jRc*, because the carriage is positioned near the edge of the disk. With the carriage near the edge, fewer turns of the disk will produce the ten revolutions of the roller needed to match *cR* and *R*. *jdR* will be relatively small.



How rate control corrects RATE OF CLIMB TARGET SPEED and TARGET ANGLE







So far, the method has been shown by which the three Rate Control Corrections, Range Rate Control Correction, *jdR*, Elevation Rate Control Correction, *jEc*, and Bearing Rate Control Correction, *jBc*, go into the Rate Control Computing Mechanism.

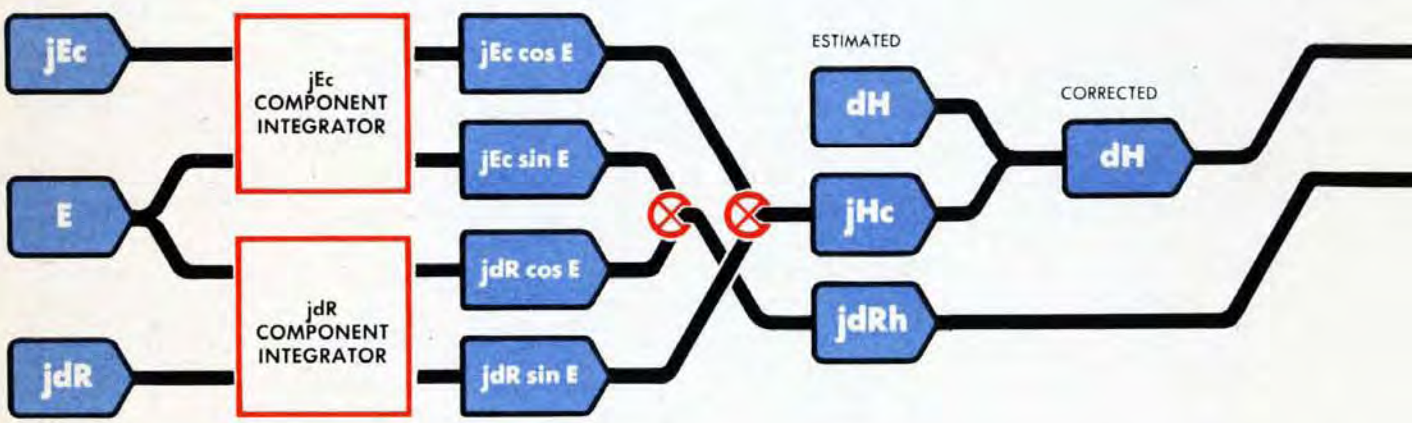
Inside that mechanism, four Component Integrators and the Vector Solver use these corrections to correct the Target Motion values, *dH*, *Sh*, and *A*.

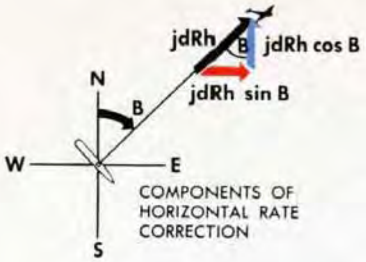
The Elevation Rate Correction, *jEc*, and Target Elevation, *E*, are the inputs to the first component integrator. The outputs are the horizontal and vertical components of *jEc*: *jEc* sin *E* and *jEc* cos *E*.

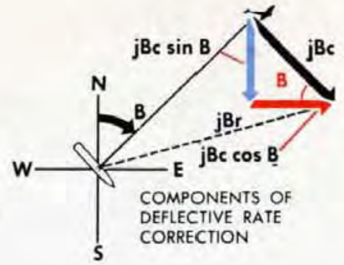
The inputs to the second component integrator are the Range Rate Correction, *jdR*, and Target Elevation, *E*.

The outputs are the horizontal and vertical components of *jdR*: *jdR* cos *E* and *jdR* sin *E*.

The *horizontal* components from the two integrators are subtracted to obtain the Horizontal Range Rate Correction, *jdRh*. The *vertical* components from the two integrators are added to give the total vertical correction, *jHc*. *jHc* is used to correct Target Rate of Climb, *dH*.



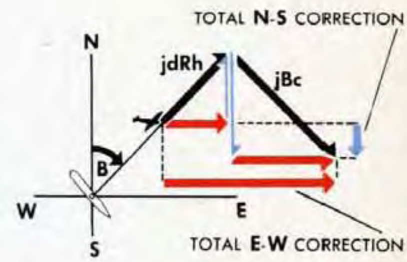




Two more component integrators break up the Horizontal Range Rate Correction, *jdRh*, and the Deflection Rate Correction, *jBc*, into their components along a North-South and East-West axis. The angular input to each of these component integrators is Target Bearing, *B*.

The N-S component of *jBc* is subtracted from the N-S component of *jdRh* to give the total N-S Horizontal Rate Correction.

The two E-W components are added to give the total E-W Horizontal Rate Correction.



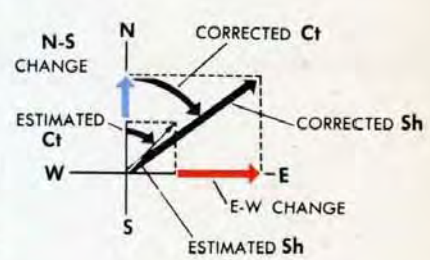
The Vector Solver corrects Sh and Ct

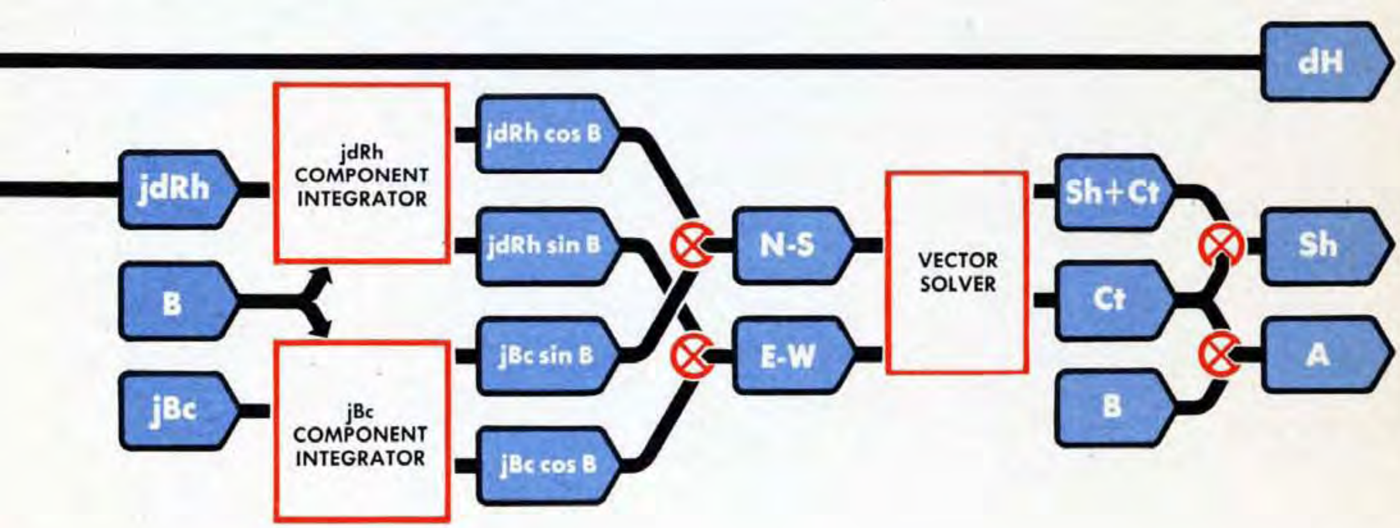
The N-S and the E-W Horizontal Rate Corrections go to the Vector Solver.

The Vector Solver was previously positioned by the estimated values of Target Speed, *Sh,* and Target Course, *Ct*. The corrections from the Rate Control Component Integrators are added to the values of *Sh* and *Ct* already in the Vector Solver. The Vector Solver's outputs are therefore *corrected values* of Target Speed and Target Course.

For mechanical reasons the two outputs of the Vector Solver are *(Sh + Ct)* and *Ct*. The *Ct* output is subtracted from the *Sh + Ct* output to obtain the corrected value of *Sh*. The *Ct* output is also subtracted from True Bearing, *B,* to obtain the corrected value of Target Angle, *A*.

The new values of *Sh* and *A* go to the Target Component Solver in the Relative Motion Group.





Another way to think about rate control

Suppose that the Control Officer can visualize his guesses of Target Motion by having a "ghost" plane that will fly according to his estimates.

Imagine that the ghost pilot will fly his ghost plane to any desired position in the sky and then fly at any speed and in any direction he is told. His plane will be visible to the Director Operators, but not to the enemy. The ghost pilot will agree not to be disturbed by anti-aircraft fire that hits his plane instead of the enemy plane. The obedient ghost is now ready to obey orders.

The ghost plane could be ordered to go to the target plane and then to fly according to the Control Officer's initial estimates of Target Angle, Target Speed, and Rate of Climb.

Suppose the ghost plane should drop below the target and fly off to its right. This would tell the Control Officer that his guesses were wrong. It would also help him correct them.

He would make corrections to his guesses of Target Course and Rate of Climb and order the ghost plane back to the target.

Suppose now that the ghost plane, flying according to these corrected values, remains on about the same course and level as the target but falls behind it.

The Control Officer would correct his Target Speed guess, order the ghost plane back to the target plane, and again instruct it to proceed at the corrected rates.

With each correction the Control Officer makes, the ghost plane flies closer and closer to the course and speed of the target.

Finally, when all three Target Motion values are corrected, the ghost plane flies right along with the target plane.

Parallel between the ghost plane story and rate control

The ghost plane represents in a general way what the Computer is thinking about the Target. More specifically, the movement of the ghost plane corresponds to the changes of Target position generated by the Computer.

1 Ordering the ghost plane initially to go up to the target corresponds to setting into the Computer the initial observed Target position inputs of Range, Elevation, and Relative Bearing.

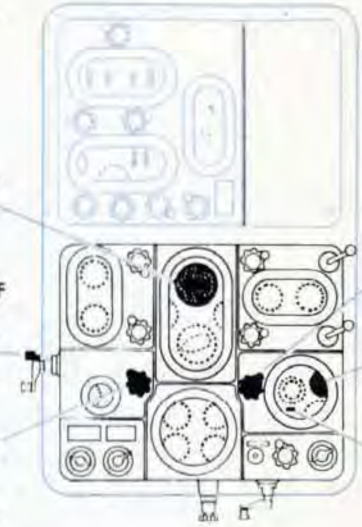
2 Ordering the ghost plane to fly at an estimated speed and direction corresponds to putting into the Computer the initial estimates of Target Speed, Target Angle, and Rate of Climb.

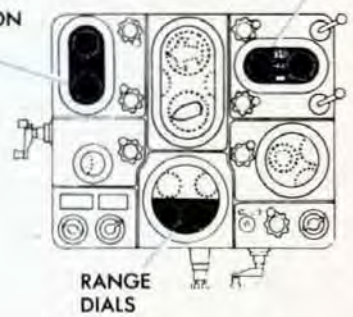
3 Watching the flight of the ghost plane vary from that of the real plane represents the comparison of the movements of the "generated dials" with the "observed dials." The movements of the Generated Elevation and Bearing Inner Dials, and the Generated Range Outer Dials, represent the behavior of the *ghost* plane. The movements of the Observed Elevation and Bearing Outer Dials, and the Observed Range Inner Dials, represent the observed movement of the *real* plane.

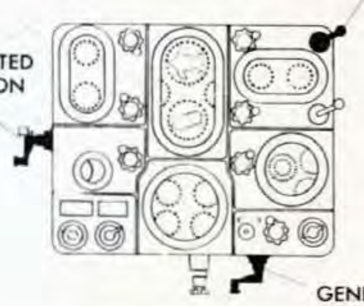
4 Ordering the ghost plane back to the Target corresponds to matching the Generated Range Dials with the Observed Range Dials. (This is not done with the Generated Elevation and Bearing Dials in the Computer Mark 1.)

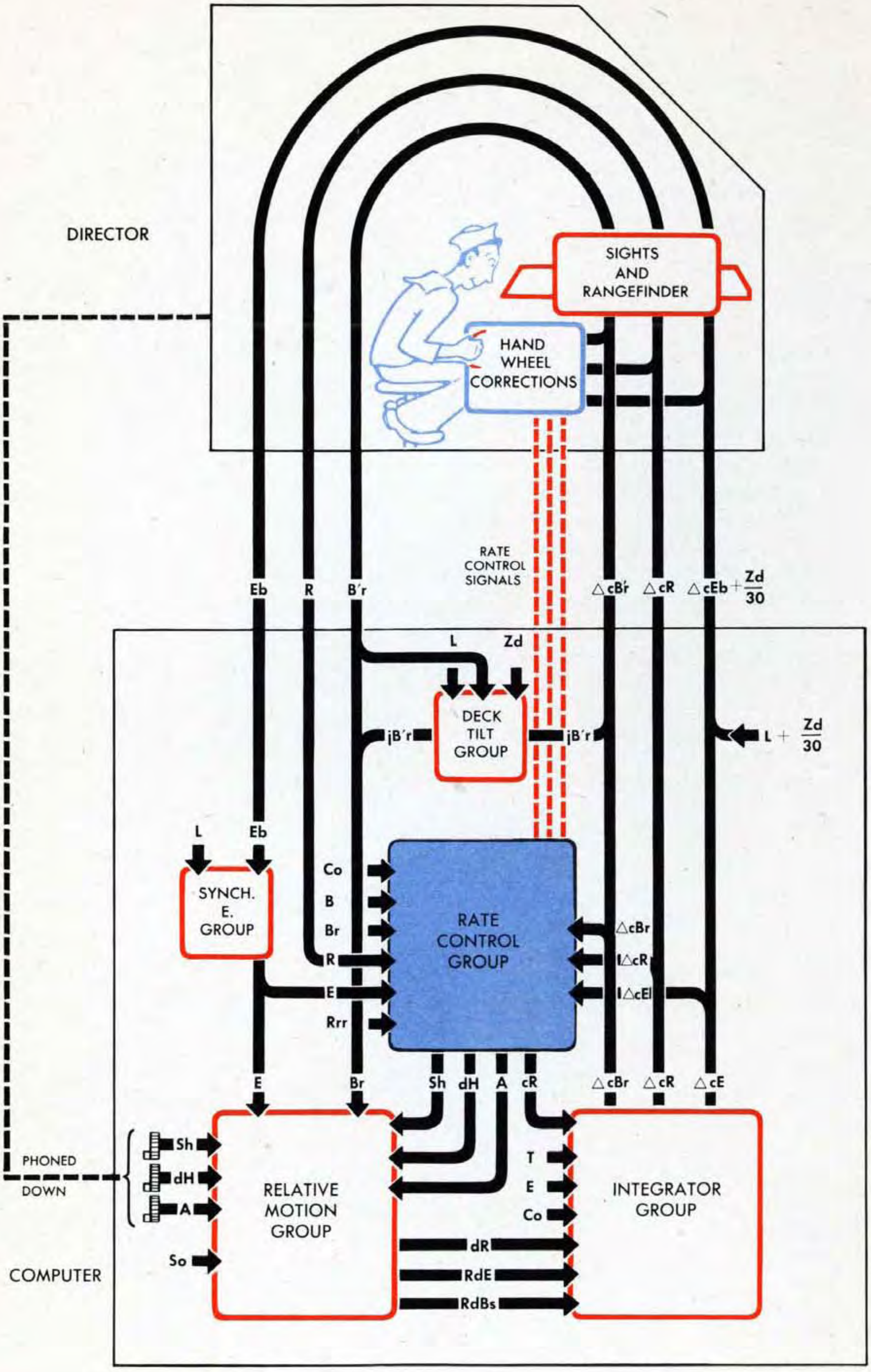
5 Ordering the ghost plane to fly at a corrected speed and direction corresponds to putting in *corrections* to Target Speed, Target Angle, and Rate of Climb. These corrections might be estimated and put in by hand, or they could be computed in the Rate Control Mechanism.

6 When the Target Motion values are correct, the ghost plane flies wing to wing with the Target and the generated dials will turn exactly with the observed dials. This is the same as saying that when the Target Motion estimates are correct, the Relative Motion Rates are correct, and the Generated Changes of Range, Elevation, and Bearing are correct. Since the generated changes continuously position the Director sights, the sights will now stay on the Target. The Relative Motion Rates on which predictions are based will be correct.








DIRECTOR
SIGHTS AND RANGEFINDER
HAND WHEEL CORRECTIONS
RATE CONTROL SIGNALS
Eb
R
B′r
△cBr
△cR
△cEb + Zd/30
L
Zd
DECK TILT GROUP
jB′r
L + Zd/30
L
Eb
SYNCH. E. GROUP
Co
B
Br
R
E
Rrr
RATE CONTROL GROUP
△cBr
I△cR
I△cE
E
Br
Sh
dH
A
cR
△cBr
△cR
△cE
Sh
dH
A
So
PHONED DOWN
RELATIVE MOTION GROUP
T
E
Co
INTEGRATOR GROUP
dR
RdE
RdBs
COMPUTER

The RATE CONTROL GROUP completes the tracking section

Here is the whole Tracking Section of the Computer Mark 1, showing how the Rate Control Group fits in, how the corrected Target values go to the Relative Motion Group, and how the Relative Motion Rates are corrected.

Rate Control is a continuous process. One set of Rate Control corrections will not completely correct the Target values, but each time a set of corrections is put into the Rate Control group, the Target values become more nearly correct.

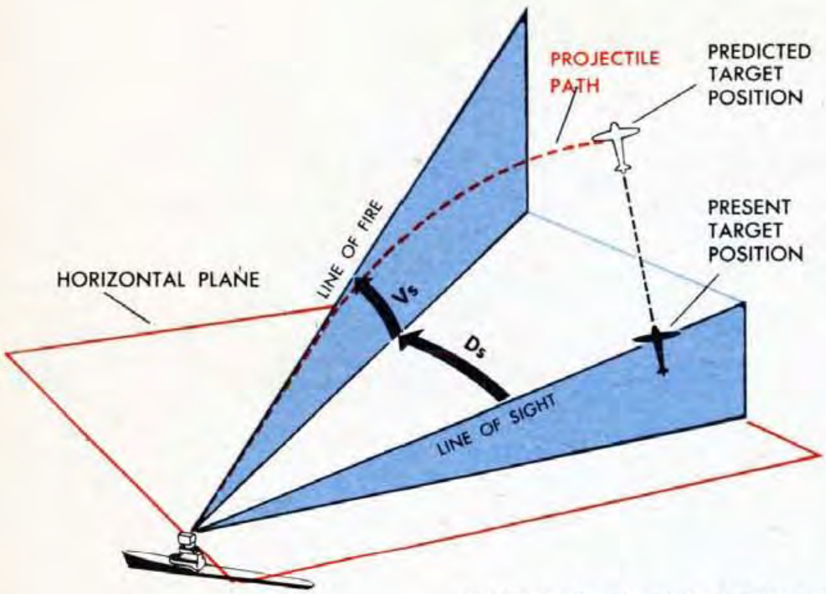
The corrected Target values are used to generate a new set of changes in Target Position which are continuously compared with the Observed Changes. The differences are again used for new Rate Control corrections, and so on, in a continuous regenerative cycle.

When the changes of Target Position generated by the Computer are equal to the Observed Changes of Target Position, a tracking solution is reached and no more Rate Control is necessary as long as the Target continues at the same speed and in the same direction.

Small variations in Target Speed and Direction can be put into the Computer by means of the Rate Control mechanism alone, but where the changes of Target Speed and Direction are large and sudden, the corrections to *Sh, A,* and *dH,* can be put into the Computer much faster by direct hand correction at the Target Speed, Target Angle, and Rate of Climb Knobs.

The new Target values are estimated at the Director and phoned down to the Computer. Then the Rate Control process starts all over again to correct these new estimates.

THE PREDICTION SECTION



The Prediction Section establishes the Line of Fire by computing two lead angles:

1 Sight Angle, *Vs*
2 Sight Deflection, *Ds*

When the deck is horizontal the two lead angles, *Vs* and *Ds*, are: the angle in Elevation, and the Deflection in the slant plane between the Line of Sight and the Line of Fire.

To aid in computing these two lead angles, two other prediction quantities must be computed:

1 Advance Range, *R2*
2 Predicted Elevation, *E2*

R2 and *E2* are also needed for computing quantities in other sections of the Computer.

The whole Prediction Section is based on calculations from a horizontal plane. Any corrections to the Line of Fire made necessary by tilting of the deck are computed in the Trunnion Tilt Section.

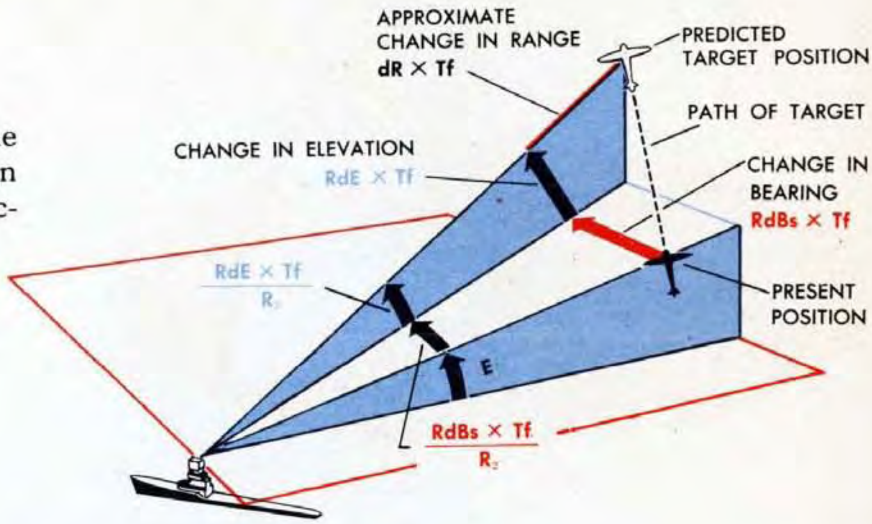
In establishing the Line of Fire, the Prediction Section makes two types of computations:

1 It computes the position of the Target at the end of the Time of Flight, allowing for the effect of Relative Motion during the time the projectile is in the air.

2 It computes how far away from this Predicted Target Position the guns must be positioned to allow for the curvature of the projectile path. Allowances are made for the effect of wind, drop of the projectile due to gravity, drift due to projectile rotation and changes in initial projectile velocity.

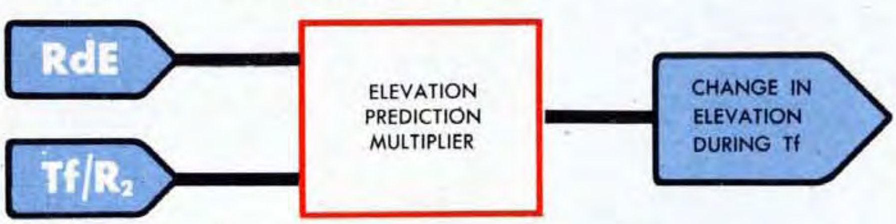
The prediction multipliers

Target Position at the end of the Time of Flight is predicted in Range, in Elevation, and in Deflection.

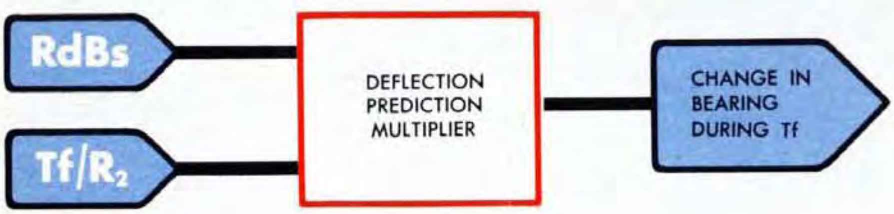


The approximate change of Range during the Time of Flight is computed by multiplying Range Rate, *dR*, by Time of Flight, *Tf*, in the Range Prediction Multiplier.

The change of Elevation during the Time of Flight is an ANGULAR quantity; therefore Elevation Rate, *RdE*, must be multiplied by *Tf* and then divided by *R2* to obtain the approximate angular Elevation changes. *RdE* is multiplied by *Tf/R2* in the Elevation Prediction Multiplier.



The change of Bearing during *Tf* is also an angular quantity, Deflection Rate, *RdBs*, is therefore multiplied by *Tf/R2* in the Deflection Prediction Multiplier.

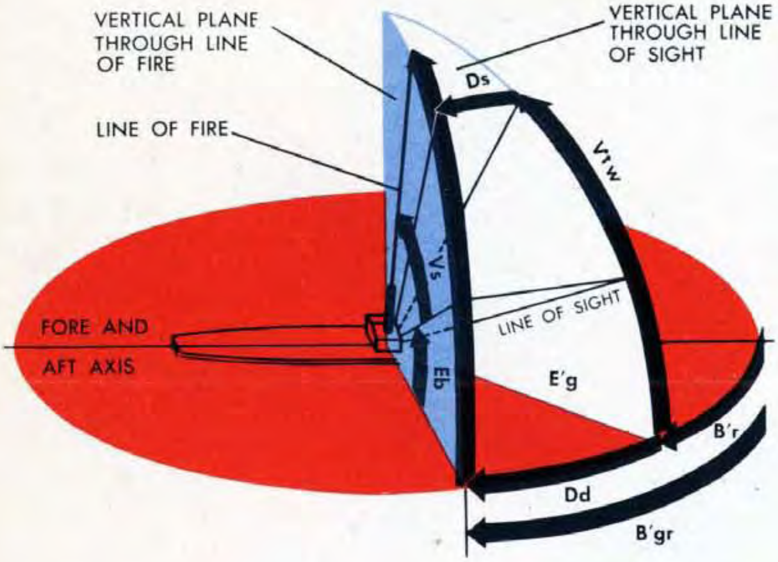


NOTE: Calculations needed to allow for curvature of the projectile path are more complex. They are explained in the Detailed Description chapter on *Prediction*.

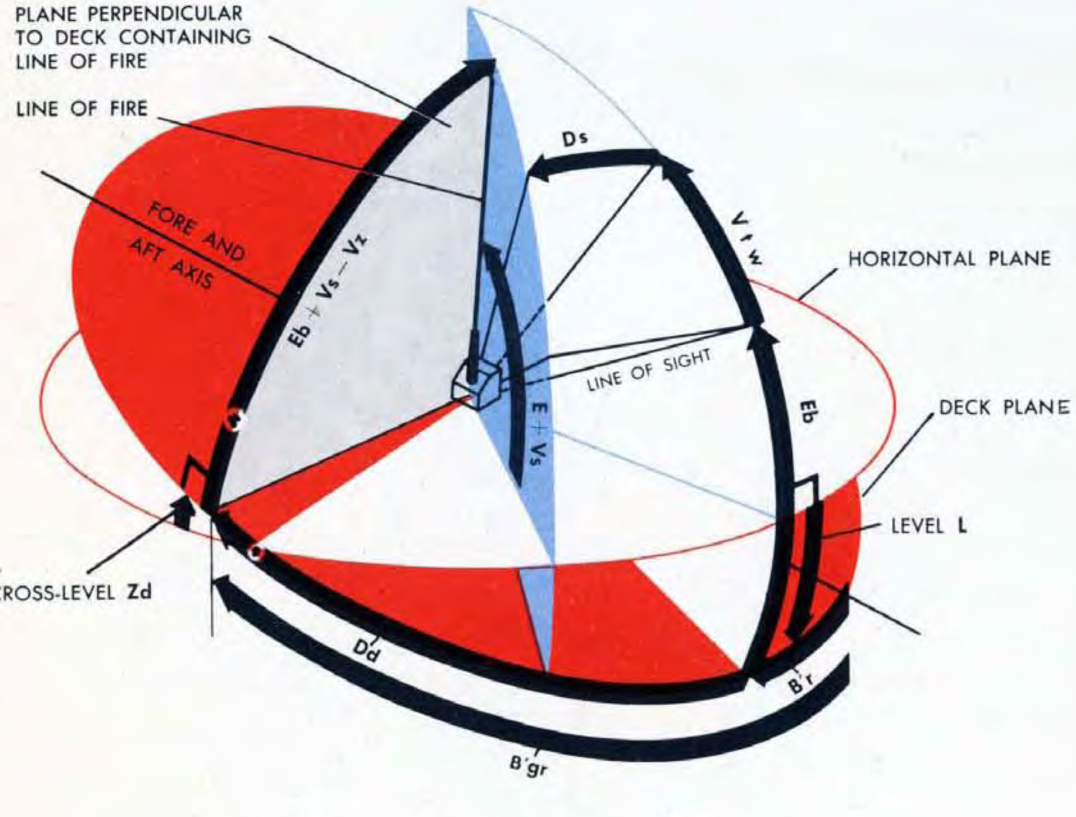
THE TRUNNION TILT SECTION

The Trunnion Tilt Section has two outputs. One is *Vz*, a correction to gun elevation to compensate for the effect on gun elevation of the tilting of the gun trunnions. The second output is Deck Deflection, *Dd*, which consists of *Ds* referred to the deck plane plus a train correction to compensate for the effect on gun train of the tilting of the gun trunnions.

The values of *Vz* and *Dd* increase and decrease continuously as Own Ship pitches and rolls. The function of these two corrections is to keep the gun aim steady in spite of the continuous tilting of the gun trunnions due to pitch and roll of the deck.



THIS IS HOW THE LINE OF FIRE IS ESTABLISHED ON A HORIZONTAL DECK



THIS IS HOW THE LINE OF FIRE IS ESTABLISHED ON A TILTED DECK

The Trunnion Tilt Elevation Correction, *Vz*, is computed in two multipliers. The values used to compute *Vz* are *Zd*, *Vs*, *Ds*, and *Eb*.

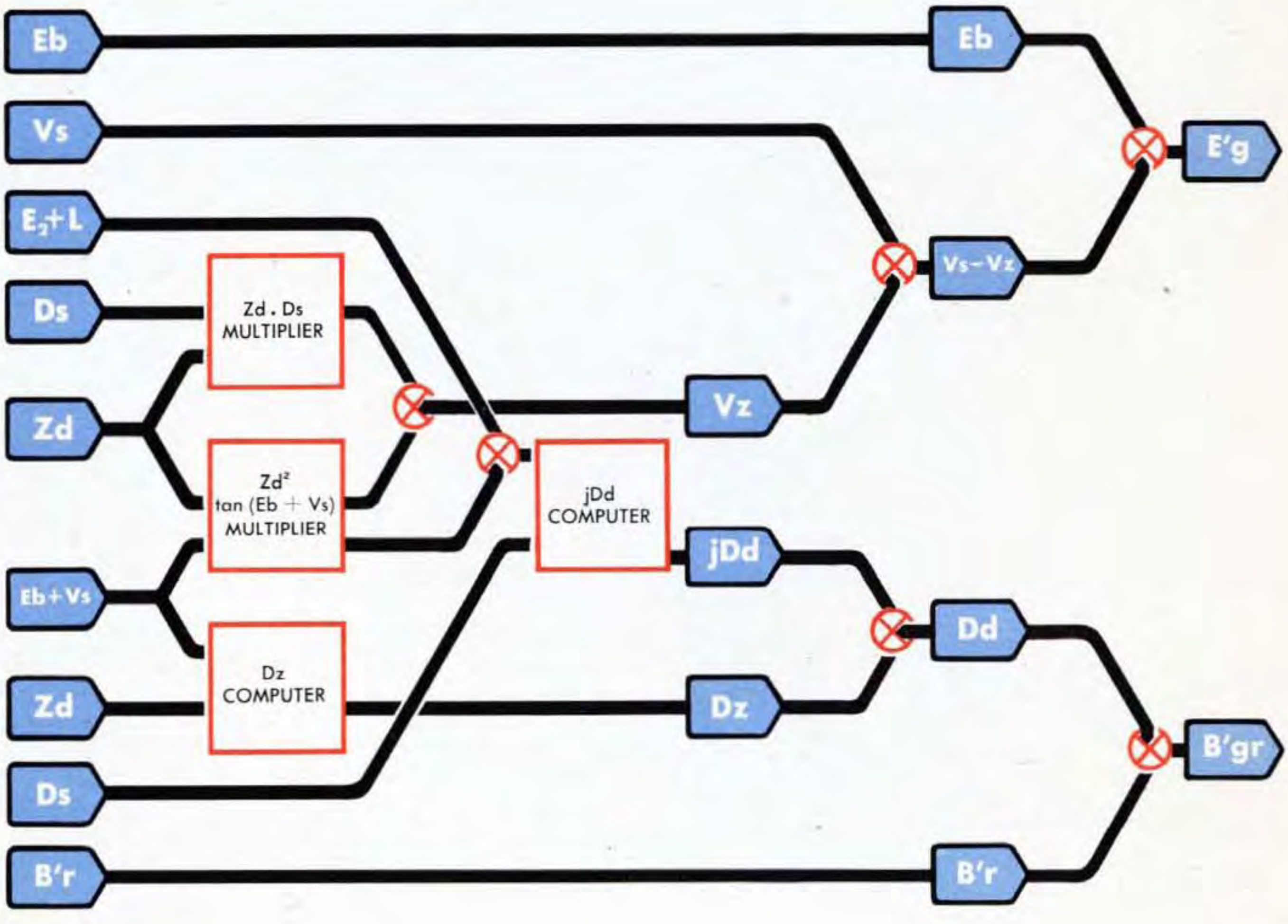
Vz is subtracted from *Eb* + *Vs* to produce the Gun Elevation Order, *E'g*.

The Trunnion Tilt Train Correction, *Dd*, consists of two quantities, *jDd* and *Dz*. *jDd* is roughly Sight Deflection, *Ds*, corrected to the deck plane and for the effect of Level. *Dz* is approximately the part of the Train Correction needed to compensate for the effect of Cross-level.

jDd and *Dz* are each computed in a special computer. The inputs are the same values as those used for *Vz* with the addition of *E2* + *L*. The outputs of the two computers are added to give Deck Deflection, *Dd*.

Deck Deflection, *Dd*, is added to *B'r* to give the Gun Train Order, *B'gr*.

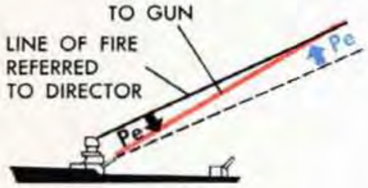
Both gun orders, *E'g* and *B'gr*, are continuously and automatically transmitted to the gun mounts to operate the machinery controlling the actual pointing and training of the guns.



PARALLAX CORRECTIONS

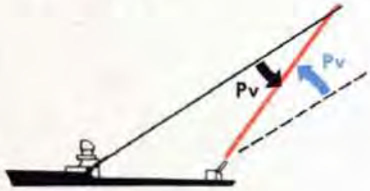
The Line of Fire is established by the Computer from a certain reference point. The reference point is usually the Director when there is only one Director on board; if there are several Directors, the reference point may be either one of the Directors or a point chosen arbitrarily.

If a gun is at the reference point, it can use the Gun Orders without further correction. If a gun is anywhere else on the deck, its aim must be corrected to compensate for the horizontal distance between the reference point and that particular gun.

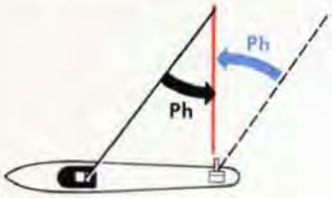


The corrections to compensate for this difference in location are the Parallax Corrections. The Parallax Section of the Computer Mark 1 computes two Parallax Corrections, one to Gun Elevation, called *Pv*, and one to Gun Train, called *Ph*. A third Parallax Correction, *Pe*, is computed on a ballistic cam along with Superelevation, *Vf*.

Pe compensates for the difference in height between the guns and reference point and is included in the Gun Elevation Order.



Both *Pv* and *Ph* are corrections to compensate for a 100-yard horizontal distance between the guns or Director and the reference point.



The Parallax Elevation Correction, *Pv*, is largest when the Target is straight ahead or astern of Own Ship.

The Parallax Train Correction, *Ph*, is largest when the Target is abeam of Own Ship.

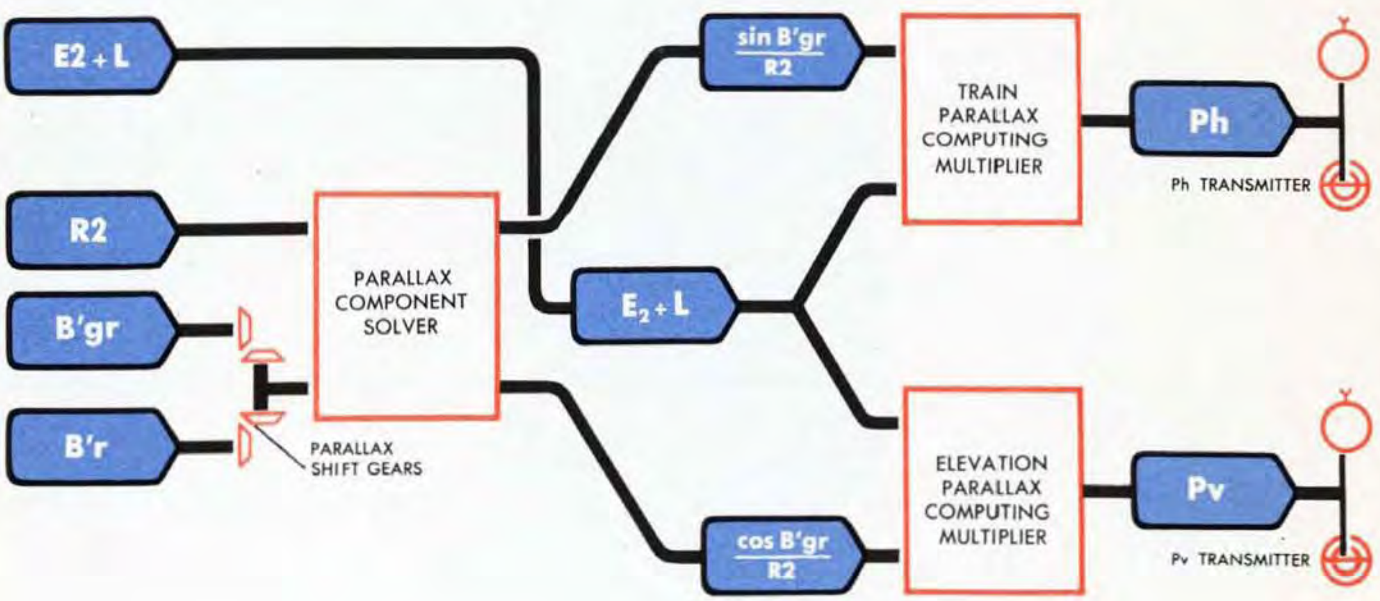
Pv and *Ph* are transmitted to the gun mounts separately from the Gun Orders. Each gun uses a fraction of each correction proportional to its own distance from the reference point. For example, a gun 50 yards from the reference point would use half of *Pv* and half of *Ph*. A gun 20 yards from the reference point would use one fifth of each correction, and so on.

The Parallax Section of the Computer Mark 1 contains a component solver, two single-cam computing multipliers, and two single-speed transmitters.

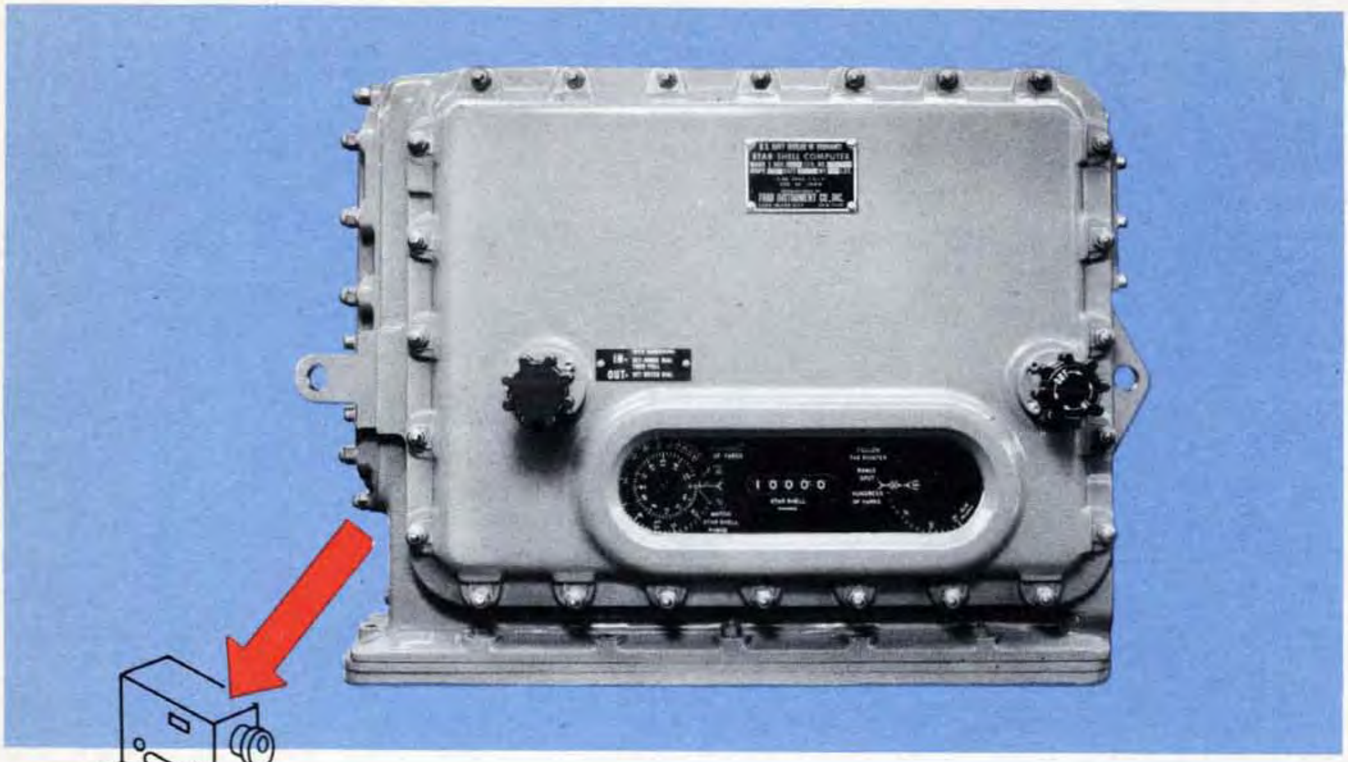
The values used in computing the Parallax Corrections are *E2 +L*, *R2*, and either *B'r* or *B'gr*. *B'r* is used on BB's, CA's, CV's, CBB's, and some CL's; *B'gr* is used on DD's, some AD's, AV's, and all ships having only one Director.

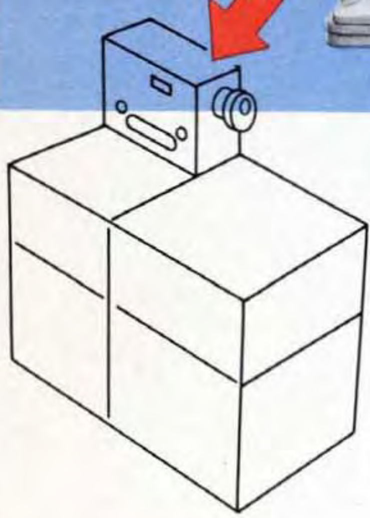
The outputs of the Parallax Section are *Pv* and *Ph*, which are transmitted electrically to the gun mounts. *Ph* is also transmitted to all Directors except those being used as a reference point. In the Directors, *Ph* is used to correct Director Train, *B'r*.

By correcting the Director Train for parallax, the values of *B'r* coming from all Directors on one ship are made uniform and the observations from any Director can be used for any or all guns aboard.



THE STAR SHELL COMPUTER MARK 1





This is the Star Shell Computer. Its job is to compute Gun and Fuze Orders for a 5″/38 cal. gun firing star shells to illuminate surface targets.

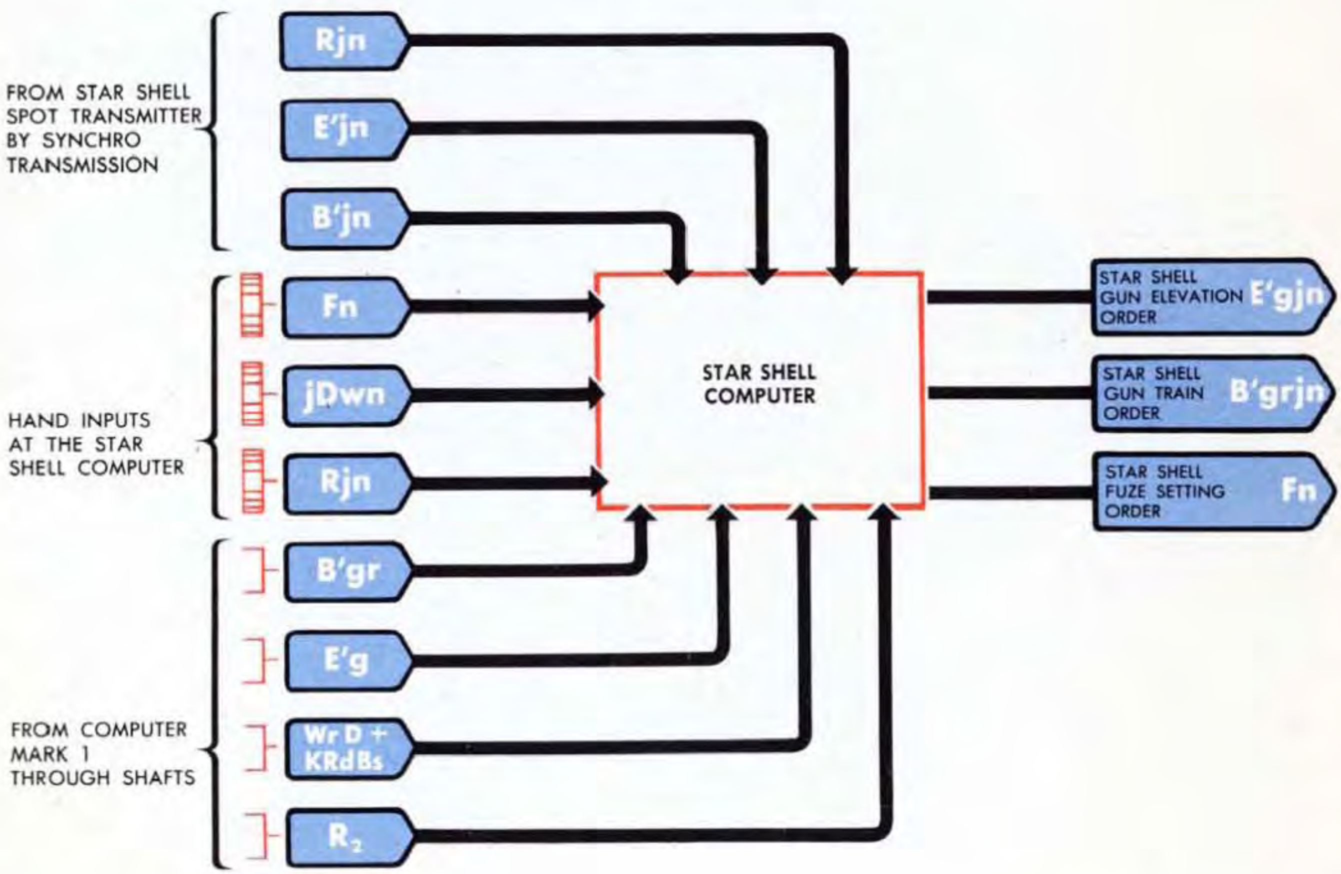
Star shells are projectiles containing a flare attached to a parachute. When the star shell bursts, the flare lights up and burns for about one minute as it floats down.

The star shells are fired at night to illuminate a given surface target or to search an area for possible targets.

When star shells are used for searching an area, the Star Shell Computer Mark 1 is NOT used. The guns are pointed according to ship's doctrine. Later mods of the Star Shell Computer provide for star shell search fire.

The Star Shell Computer receives the Gun Orders from the Computer Mark 1. These Gun Orders point the guns to HIT a given target. The Star Shell Computer adds corrections to these Gun Orders which point a gun to ILLUMINATE that same target. The Gun and Fuze Orders from the Star Shell Computer place a star 1000 yards beyond the target, 1500 feet above the target, and with a deflection such that it is directly beyond the moving target after it has been burning 30 seconds (half its life).

The inputs and outputs of the Star Shell Computer are shown in the schematic. The hand inputs need some explanation. Fuze Setting Order, *Fn*, and Angular Deflection, *jDwn*, are put in by matching the readings of the two Star Shell Range Dials with the reading on the Star Shell Range Counter. The matching is done with a two-position knob. *Rjn* is a hand input based on information received by synchro transmission. Star Shell Range Spot, *Rjn*, is sent by synchro transmission from the Star Shell Spot Transmitter to a synchro motor and dial in the Star Shell Computer. The value of *Rjn* which shows on the dial must be put into the Star Shell Computer mechanisms by hand. By turning a knob, the index on the Range Spot Ring Dial can be matched with the pointer on the receiver dial, thus putting in the value of *Rjn*



INPUTS and OUTPUTS of the COMPUTER MARK 1 and the

INPUTS

1 Inputs from the Director

Observed Target Position (By synchro transmission)	*R*	Observed Range
	Eb	Director Elevation
	B'r	Director Train
Estimated Target Motion (By phone to the Computer Operators, and initially set in manually)	*Sh*	Horizontal Target Speed
	dH	Rate of Climb
	A	Target Angle, or
	Ct	Target Course
Rate Control Signals (By electrical signal)	*jdR*	Range Rate Control Correction
	jE	Elevation Rate Control Correction
	jBr	Bearing Rate Control Correction
Spot Correction to the Computer Mark 1 (By synchro transmission)	*Rj*	Range Spot
	Vj	Elevation Spot
	Dj	Deflection Spot
Spot Corrections to the Star Shell Computer (By synchro transmission)	*Rjn*	Star Shell Range Spot
	E'jn	Star Shell Elevation Spot
	B'jn	Star Shell Deflection Spot
2 Inputs from the Stable Element (By shafts)	*L*	Level
	Zd	Cross-level
	L+Zd/30	Level plus function of Cross-level
3 Inputs from the Gyro Compass (By synchro transmission)	*Co*	Ship Course
4 Inputs from the Pitometer Log (By synchro transmission)	*So*	Ship Speed
5 Hand Inputs		
Quantities that can be put in by hand only	*Sw*	Wind Speed
	Bw	Wind Direction
	I.V.	Initial Velocity
	Tg	Dead Time
	Rrr	Range Rate Ratic
	Dip	Dip Angle
Alternate hand inputs for quantities normally received electrically	*cR*	Range (Alternate input for *R*)
	E	Elevation (Alternate input for *Eb*)
	Br	Relative Bearing (Alternate input for *B'r*)
	Rj	Range Spot
	Vj	Elevation Spot
	Dj	Deflection Spot
	Co	Ship Course
	So	Ship Speed

STAR SHELL COMPUTER MARK 1

Hand inputs that may be used during Rate Control	jdR	Rate Control Correction through Generated Range Crank
	jE	Rate Control Correction through Generated Elevation Crank
	jBr	Rate Control Correction through Generated Bearing Crank
	Sh	Horizontal Target Speed
	dH	Rate of Climb
	Ct	Target Course
	A	Target Angle
Hand inputs to the Star Shell Computer	Rjn	Star Shell Range Spot
	Fn	Star Shell Fuze Setting Order
	jDwn	Angular Deflection of Star

OUTPUTS

1 To the Gun Mounts (By synchro transmission)

To the Train Indicator Regulator	B'gr	Gun Train Order
	B'grjn	Star Shell Gun Train Order
	Ph	Train Parallax Correction (also goes to some Directors)
To the Elevation Indicator Regulator	E'g	Gun Elevation Order
	E'gjn	Star Shell Gun Elevation Order
	Pv	Elevation Parallax Correction (also goes to some Directors)
To the Sights	Vs	Sight Angle
	Ds	Sight Deflection
To the Fuze Setting Indicator Regulator	F	Fuze Order

2 To the Director (By synchro transmission)

To the Change of Range Receiver at the Range Finder	ΔcR	Generated Changes of Range
To the Elevation Receiver	$\Delta cEb + Zd\ 30$	Generated Changes of Director Elevation plus Function of Cross-level
To the Train Receiver	$\Delta cB'r$	Generated Changes of Director Train

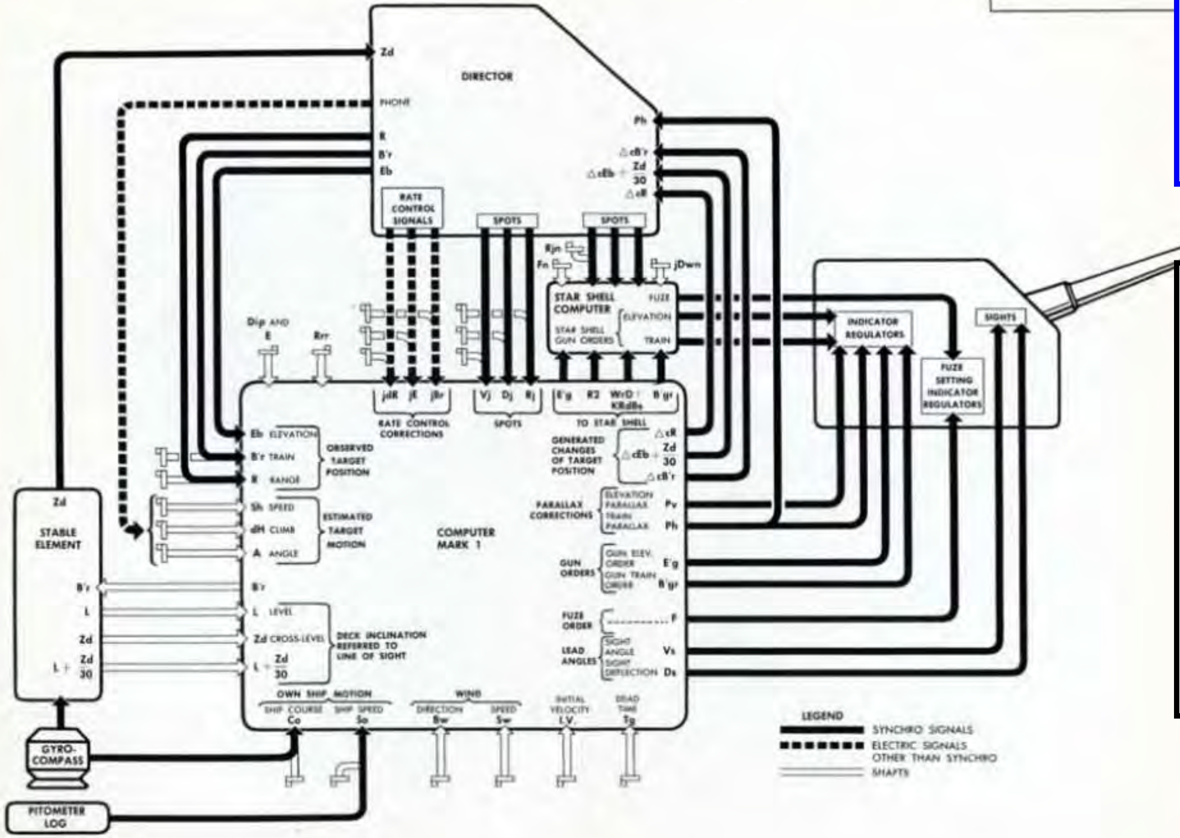
3 To the Stable Element (By shaft)

	B'r	Director Train

4 To the Star Shell Computer (By shafts)

	E'g	Gun Elevation Order
	B'gr	Gun Train Order
	R2	Advance Range
	Wrd + KRdBs	Deflection Wind plus Function of Deflection Rate

COMPUTER MK 1, MOD
COMPUTER INPUTS and OUTPU



Summary of COMPUTER MARK 1 DATA

Size

Without handcranks the Computer Mark 1 measures approximately:

62 inches long
38 inches wide
45 inches high

With the Star Shell Computer Mark 1 in place the all-over height is 65 inches. The exact dimensions are shown below.

Weight

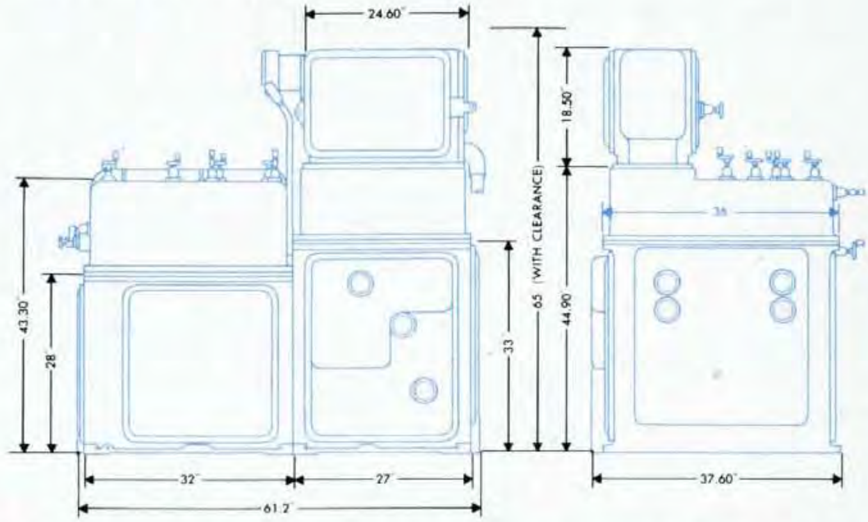
The Computer Mark 1 weighs about 3125 lbs.
The Star Shell Computer Mark 1 weighs about 215 lbs.

Power Supply

The Computer Mark 1 and the Star Shell Computer operate on 115-volt, 60-cycle, single-phase, alternating current.

The normal current, including excitation of the transmitters, is about 57½ amperes.

The maximum current, assuming the extremes in synchronization, could be as much as 140 amperes.



LIMITS OF OPERATION

INTERMITTENT DRIVES

COMPUTER MARK 1

Symbol	Lower Limit	Upper Limit
Ds	320 MILS	680 MILS
Vs	2,000′	3,800′
E2	0°	90°
Eb + Vs	1,640′	7,160′
dRs	− 450 KNOTS	+ 450 KNOTS
cR	750 YARDS	22,500 YARDS
E	− 2°	+ 85°

LIMIT STOPS

COMPUTER MARK 1

Stop No.	Symbol	Lower Limit	Upper Limit	
L-1	So	0 KNOTS	45 KNOTS	
L-2	Sh	0 KNOTS	400 KNOTS	
L-3	Sw	0 KNOTS	60 KNOTS	
L-4	dH	−250 KNOTS	+150 KNOTS	
L-5	dRh	−440 KNOTS	+440 KNOTS	
L-6	RdBs	−400 KNOTS	+400 KNOTS	
L-7	RdE	−400 KNOTS	+400 KNOTS	
L-8	dR	−450 KNOTS	+450 KNOTS	
L-9	Ywgr	−100 KNOTS	+100 KNOTS	
L-10	cR	0 YARDS	35,000 YARDS	
L-11	Eb	500′	8,600′	
L-12	E	−5°	+85°	Serial Numbers below 390
		−25°	+85°	Serial Numbers above 389
L-13	Rrr	1	5	
L-14	Tg	0 SECONDS	6 SECONDS	Serial Numbers below 781
	Tg + F − Tf	0 SECONDS	50 SECONDS	Serial Numbers above 780
L-15	I.V.	2,350 f.s.	2,600 f.s.	
L-16	L	480′	3,520′	
L-17	Zd	480′	3,520′	
L-18	jB′r	348° 20′	11° 40′	
L-19	R2	500 YARDS	18,000 YARDS	
L-20	Tf/R2	0.00122	0.00336	
L-21	R2	*300 YARDS	*18,200 YARDS	
L-22	Vf + Pe	0′	2,500′	
L-23	R2	*300 YARDS	*18,200 YARDS	
L-24	Tf	0.6 SECONDS	60.6 SECONDS	
L-25	R2	*300 YARDS	*18,200 YARDS	
L-27	R3	*−1,250 YARDS	*+19,750 YARDS	
L-28	Dtwj	−518 MILS	+518 MILS	
L-29	Rj	IN 12,000 YARDS	OUT 1,800 YARDS	
L-30	Dj	LEFT 180 MILS	RIGHT 180 MILS	
L-31	Vj	DOWN 180 MILS	UP 180 MILS	
L-32	Dd	−120°	+120°	
L-34	Vz	−2,940′	+1,860′	
L-35	F	0.6 SECONDS	55.0 SECONDS	
L-36	R3	*−1,250 YARDS	*+19,750 YARDS	
L-37	V	200′	3,800′	
L-38	Tg	0 SECONDS	6 SECONDS	Serial Numbers above 780

STAR SHELL COMPUTER

L-1	WrD + KRdBs	−60 KNOTS (Read as 940 Knots on counter)	+60 KNOTS
L-2	Rjn	IN 1,500 YARDS	OUT 1,500 YARDS
L-3	Fn	8.20 SECONDS	41.55 SECONDS
L-4	jDwn	4,000 YARDS	15,000 YARDS

*Limit cannot be reached when ballistic unit containing limit stop is installed in Computer.

Name		Location: Section	Location: Cover	Value per rev.	Size	Mods
Range Correction Transmitter		Control	1	1000 yds	5 G	All
Range Receiver	Coarse	Control	1	72,000 yds	5 F	
	Fine	Control	1	2000 yds	5 F	All
Target Course Transmitter		Control	1	360°	5 G	Except Mods 0, 1, 2, 9
Elevation Correction Transmitter		Computer	3	5°	6 DG	Mod 0
Bearing Correction Transmitter		Computer	3	5°	6 G	Mod 0
Elevation Correction Ind. Transmitter		Computer	3	10°	5 G	Except Mod 0
Elevation Correction Auto Transmitter		Computer	3	5°	6 G	Except Mod 0
Bearing Correction Ind. Transmitter		Computer	3	10°	5 G	Except Mod 0
Bearing Correction Auto Transmitter		Computer	3	5°	6 G	Except Mod 0
Ship Course Receiver	Coarse	Computer	5	360°	5 B	All
	Fine	Computer	5	10°	5 F	All
Deflection Spot Receiver		Indicator	2	360 mils	5 B	All
Elevation Spot Receiver		Indicator	2	360 mils	5 B	All
Range Spot Receiver		Indicator	2	4000 yds	5 B	All
Ship Speed Receiver		Indicator	2	Various	5 B	Except Mod 0
Fuze Setting Order Transmitter	Coarse	Indicator	2	100 sec	6 G	Mods 0, 1, 2, 9
					7 G	Except Mods 0, 1, 2, 9
	Fine	Indicator	2	2 sec	6 G	Mods 0, 1, 2, 9
					7 G	Except Mods 0, 1, 2, 9
Single Mount Sight Angle Transmitter		Indicator	2	2400 min	6 G	Mods 0, 2, 7, 11, 13
					7 G	Mods 9, 10, 5, 6
Single Mount Sight Deflection Transmitter		Indicator	2	442.24 mils	6 G	Mods 0, 2, 7, 11, 13
					7 G	Mods 9, 10, 5, 6
Twin Mount Sight Angle Transmitter	Coarse	Indicator	2	7200 min	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12

Gene Slover's US Navy Pages
Quick Reference Index

Twin Mount Sight Angle Transmitter	Fine	Indicator	2	200 min	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12
Twin Mount Sight Deflection Transmitter	Coarse	Indicator	2	4000 mils	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12
	Fine	Indicator	2	100 mils	6 G	Mods 1, 9, 7, 11, 13
					7 G	Mods 3, 10, 4, 8, 12
Gun Train Order Ind. Transmitter (No. 1)	Coarse	Corrector	8	360°	7 G	All
	Fine	Corrector	8	10°	7 G	All
Gun Train Order Auto Transmitter (No. 2)	Coarse	Corrector	8	360°	7 G	All
	Fine	Corrector	8	10°	7 G	All
Director Train Receiver	Coarse	Corrector	8	360°	5 B	All
	Fine	Corrector	8	10°	5 F	All
Gun Elev. Order Ind. Transmitter (No. 1)	Coarse	Corrector	6	10,800 min	7 G	All
	Fine	Corrector	6	600 min	7 G	All
Gun Elev. Order Auto Transmitter (No. 2)	Coarse	Corrector	6	10,800 min	7 G	All
	Fine	Corrector	6	600 min	7 G	All
Director Sight Elev. Receiver	Coarse	Corrector	6	180°	5 B	All
	Fine	Corrector	6	10°	5 F	All
Train Parallax Transmitter		Corrector	6	30°/100 yds	6 G	Mods 0, 1, 2, 9
					7 G	Except Mods 0, 1, 2, 9
Elevation Parallax		Corrector	6	10°/100 yds	7 G	Mods 5, 7, 11, 13, 8, 12
Star Shell Fuze Setting Order Transmitter	Coarse	Star Shell		100 sec	6 G	All
	Fine	Star Shell		2 sec	6 G	All
Star Shell Gun Elev. Order Transmitter	Coarse	Star Shell		10,800 min	6 DG	All
	Fine	Star Shell		600 min	6 DG	All
Star Shell Gun Train Order Transmitter	Coarse	Star Shell		360°	6 DG	All
	Fine	Star Shell		10°	6 DG	All
Star Shell Range Spot Receiver		Star Shell		4000 yds	1 F	All

DESIGN FEATURES OF THE COMPUTER MARK 1

There are several important features of the Computer Mark 1 which must be grasped before the details of the Computer can be fully understood.

1 The Computer Mark 1 is designed to compute for a Target moving in a straight line at a constant speed.

The Rate Control Mechanism corrects the estimates of Target Motion set into the Computer. Once these have been corrected, the Computer will continue to compute correct Gun and Fuze Orders as long as the course and speed of the Target remain unchanged.

2 The inputs of Target Speed are Target Horizontal Speed, *Sh*, and Rate of Climb, *dH*. The air speed of the Target is NOT an input. Target Horizontal Speed, *Sh*, is the horizontal component of the Target's speed with respect to the ground. Rate of Climb, *dH*, is the vertical component of the Target's speed with respect to the ground.

Since both *Sh* and *dH* are measured with respect to the ground and not to the air, the effect of wind on the Target is already included in these speeds and need not be computed separately. For this reason the wind computations in the Computer Mark 1 are concerned only with the effect of wind on the projectiles.

3 The Range shaft lines in the Computer Mark 1 are positioned by Generated Range while the Elevation and Bearing shaft lines are positioned by Observed Elevation and Observed Bearing. One reason for this is that Elevation and Bearing are observed continuously in the Director, while Range if observed optically cannot be measured continuously.

Since Observed Range can be measured only intermittently, the motion of the Observed Range shaft line is not smooth. The Generated Range line on the other hand, moves smoothly since it is positioned by the Increments of Range from the Range Integrator. Using Generated Range to position the Range lines in the Computer therefore makes for smoother operation of all the mechanisms on this line.

Since Elevation and Bearing can be observed continuously, these observed quantities can be used to position the mechanisms in the Computer. Generated Elevation and Bearing could be used to position the mechanisms. However, the observed quantities are used in the Computer Mark 1 because they are more accurate than the generated quantities at the beginning of tracking, before the Rate Control Computing Mechanism has corrected the rates of change of the generated quantities.

4 The information stored on the ballistic cams in the Computer Mark 1 is based on trajectories which the projectile will follow when the Initial Velocity is 2550 feet per second and there is no Wind.

It is a feature of the Computer Mark 1 that it uses hand inputs of Wind Speed, Wind Direction, and actual Initial Velocity to alter the Advance Range and Advance Elevation inputs to these cams in such a way that the outputs from the cams include alterations for the effects of Wind and of variations in the Initial Velocity of the projectile.

Here is a table showing which of the variable factors in the fire control problem affect each of the outputs from the Computer Mark 1.

VARIABLES that affect the computed outputs	COMPUTED OUTPUTS: LEAD ANGLES		GUN ORDERS		FUZE SETTING ORDER
	GUN SIGHT POSITION		GUN POSITION		FUZE TIME
	Vs	Ds	E'g	B'gr	F
RELATIVE MOTION RATES	X	X	X	X	X
RANGE	X	X	X	X	X
ELEVATION	X	X	X	X	X
ROLL AND PITCH	—	—	X	X	—
DROP OF PROJECTILE	X	X	X	X	X
DRIFT OF PROJECTILE	X	X	X	X	X
TIME OF FLIGHT	X	X	X	X	X
INITIAL VELOCITY	X	X	X	X	X
WIND RANGE WIND ELEVATION WIND DEFLECTION WIND	X	X	X	X	X
DEAD TIME	—	—	—	—	X
SPOTS RANGE SPOT ELEVATION SPOT DEFLECTION SPOT	X	X	X	X	X

LEGEND: X indicates the output is affected by variable
— indicates the output is not affected by variable

PART 2

OPERATION

Part 2 identifies the operating controls, explains how the operating controls are used in various types of Computer operations, and traces through a typical operating cycle.

No explanations are given for the operating instructions. The reasons behind the operating instructions are supplied by Part 1, the *General Description*, and Part 3, the *Detailed Description*. Operation of the Computer Mark 1 is largely rate-controlling. For this reason, the chapters in the Detailed Description dealing with Relative Motion, Integrators, and Rate Control will be very useful to operators.

Part 2 is not intended to specify or supersede any *ship's doctrine*. It is not intended to imply when any particular type of operation is to be used. The four chapters in Part 2 will serve as a foundation for operating procedure when combined with the doctrine of a particular combat area and a particular ship.

The chapters in Part 2 are:

OPERATING CONTROLS

This chapter describes all of the dials, counters, handcranks, and switches which are used in operating the Computer Mark 1, the Target Course Indicator Mark 1, and the Star Shell Computer Mark 1. Dials and counters which are used only during tests are described in OP 1064A.

The dials and counters show the values of the various quantities on the Computer shaft lines. Some dials indicate the values of the quantities set in by handcranks or by automatic transmission. Other dials show the values of computed quantities. A knowledge of the location of all the dials and the quantities that can be read on them must be acquired in order to operate the Computer.

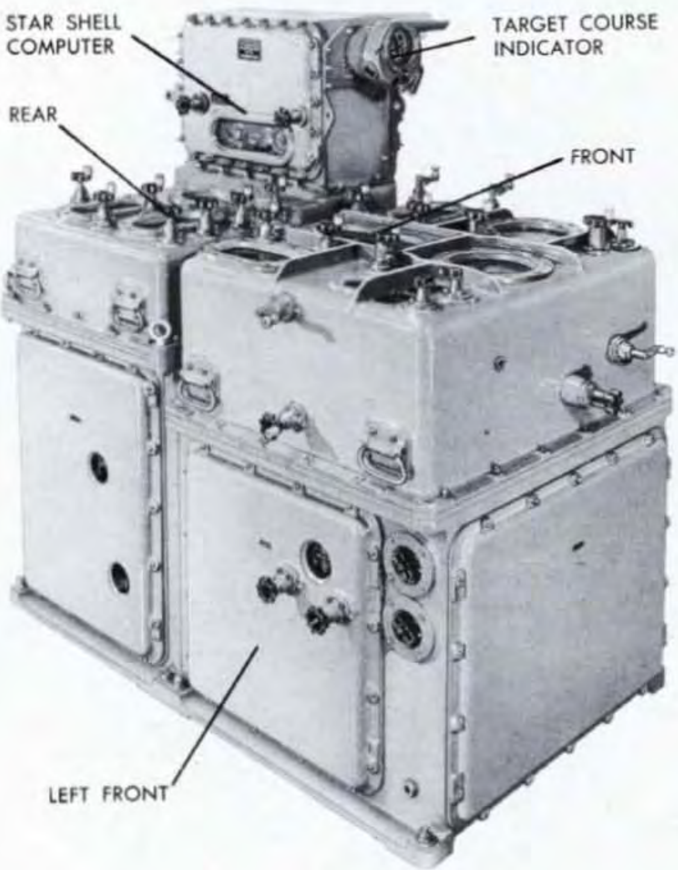
The handcranks provide a means of putting values into the Computer. In some cases a handcrank is the *only* means of putting a value into the Computer. More often the handcrank provides an *alternate* means of introducing a value when the normal automatic receivers fail. Such handcranks have a shift mechanism which allows them to be connected to or disconnected from the shaft lines, and to actuate switches to disconnect or connect the automatic receivers. A few of the handcranks are used only in the event of casualties in the fire control system.

The switches control electrical circuits in the Computer. Some of the switches are used to select a type of Computer operation, such as AUTO or SEMI-AUTO. The switches which are used for this purpose are especially important to identify because their several positions determine the ways in which various handcranks and dials are to be used.

The controls divide into five groups: the controls on the

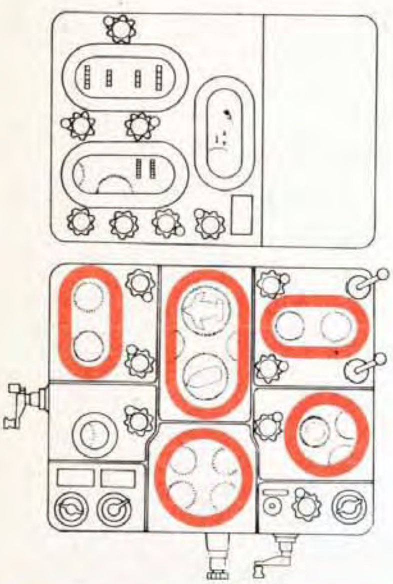
1 FRONT
2 LEFT FRONT
3 REAR
4 Target Course Indicator
5 Star Shell Computer

The front contains most of the controls used in operating the Computer and is therefore described first.



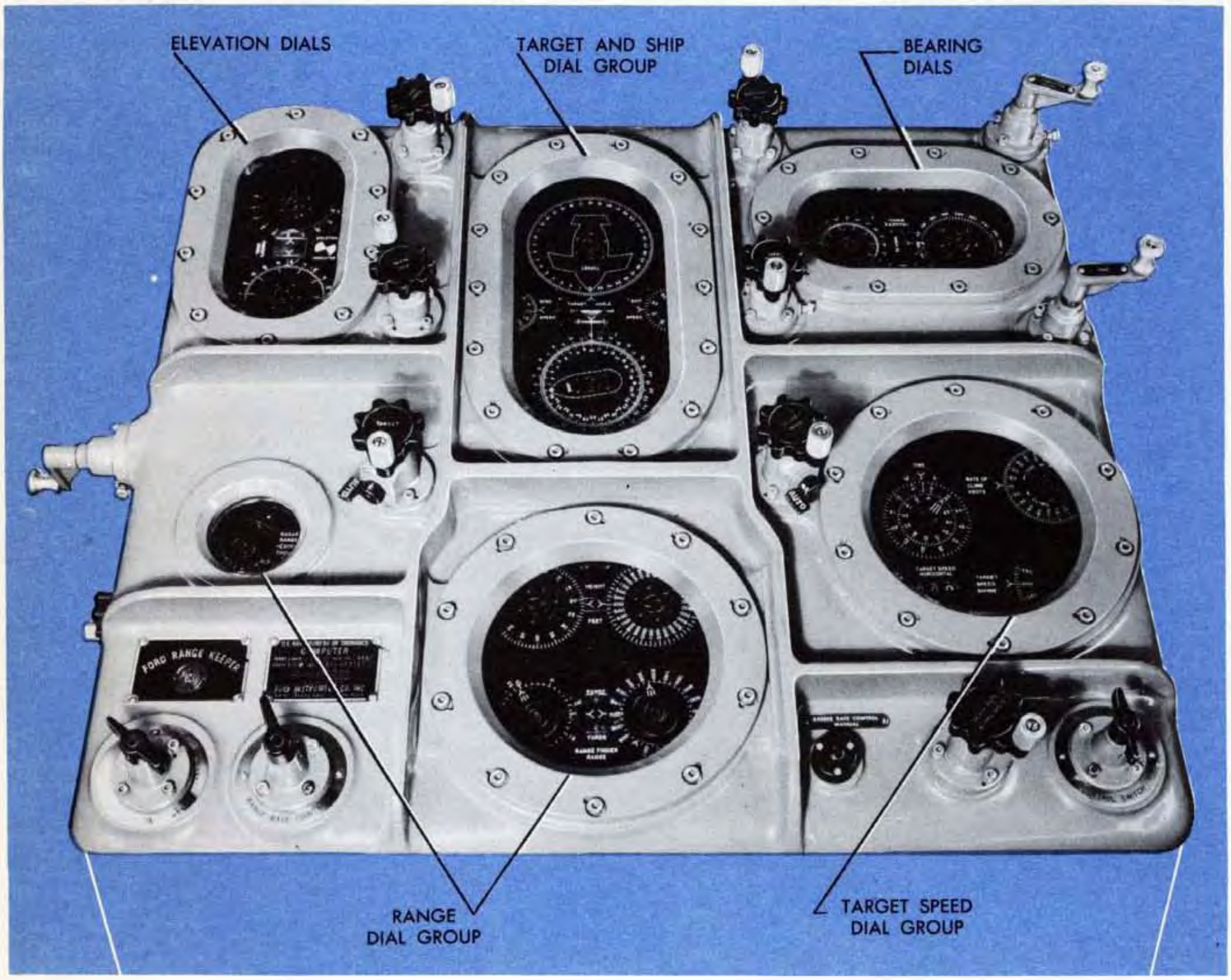
A large diagram of the Computer showing the locations and names of all the controls appears on page 109.

THE DIALS ON THE FRONT OF



The front of the Computer Mark 1 divides itself into five dial groups.

1 The TARGET AND SHIP Dial Group
2 The TARGET SPEED Dial Group
3 The RANGE Dial Group
4 The BEARING Dials
5 The ELEVATION Dials



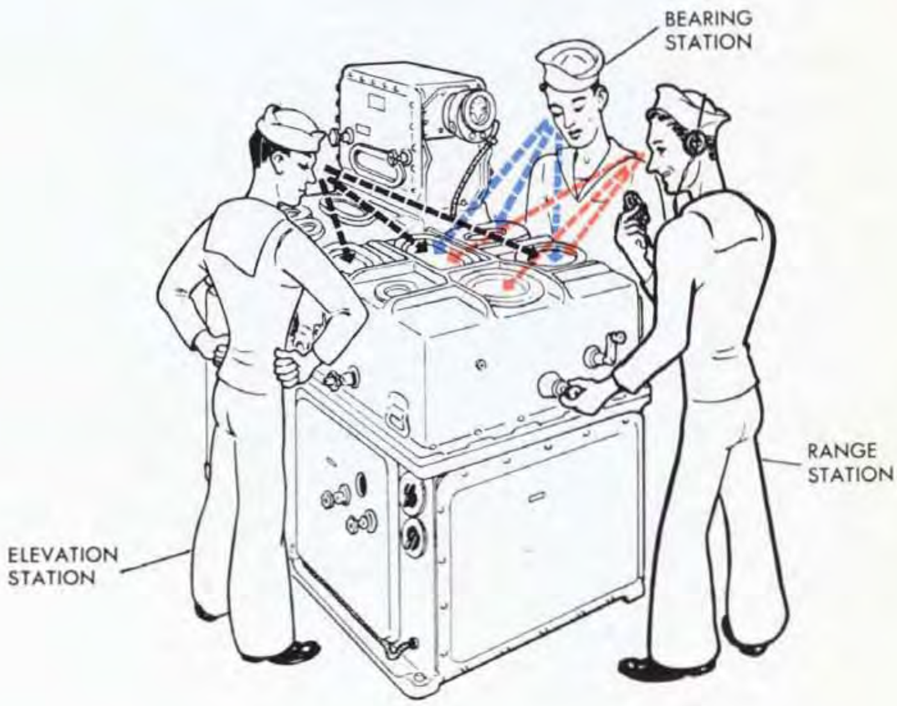
THE COMPUTER MARK 1

The five dial groups on the front of the Computer are used continuously in tracking a target. The front is operated from three operating stations: the Range Station in front of the Computer, the Bearing Station on the right side of the Computer, and the Elevation Station on the left side of the Computer. Each station may be manned by one or more operators, according to ship's doctrine.

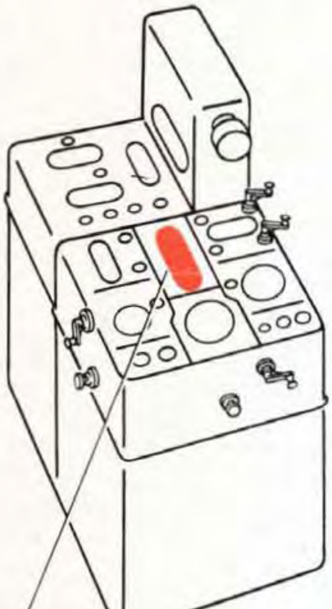
The Target and Ship Dial Group is watched by the men at all three operating stations. It is one of the most important sources of information for the operation of the Computer.

The Target Speed Dial Group is also watched by the men at all three operating stations.

Besides watching the Target and Ship Dial Group and the Target Speed Dial Group, the Range Station Operators watch the Range Dials, the Bearing Station Operators watch the Bearing Dials, and the Elevation Station Operators watch the Elevation Dials.

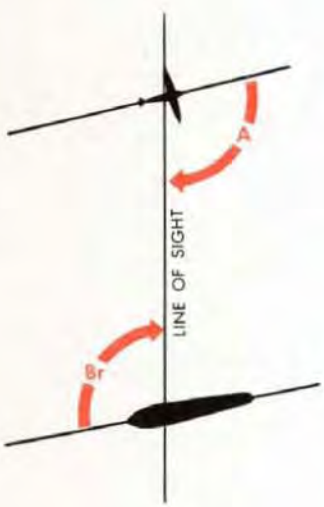


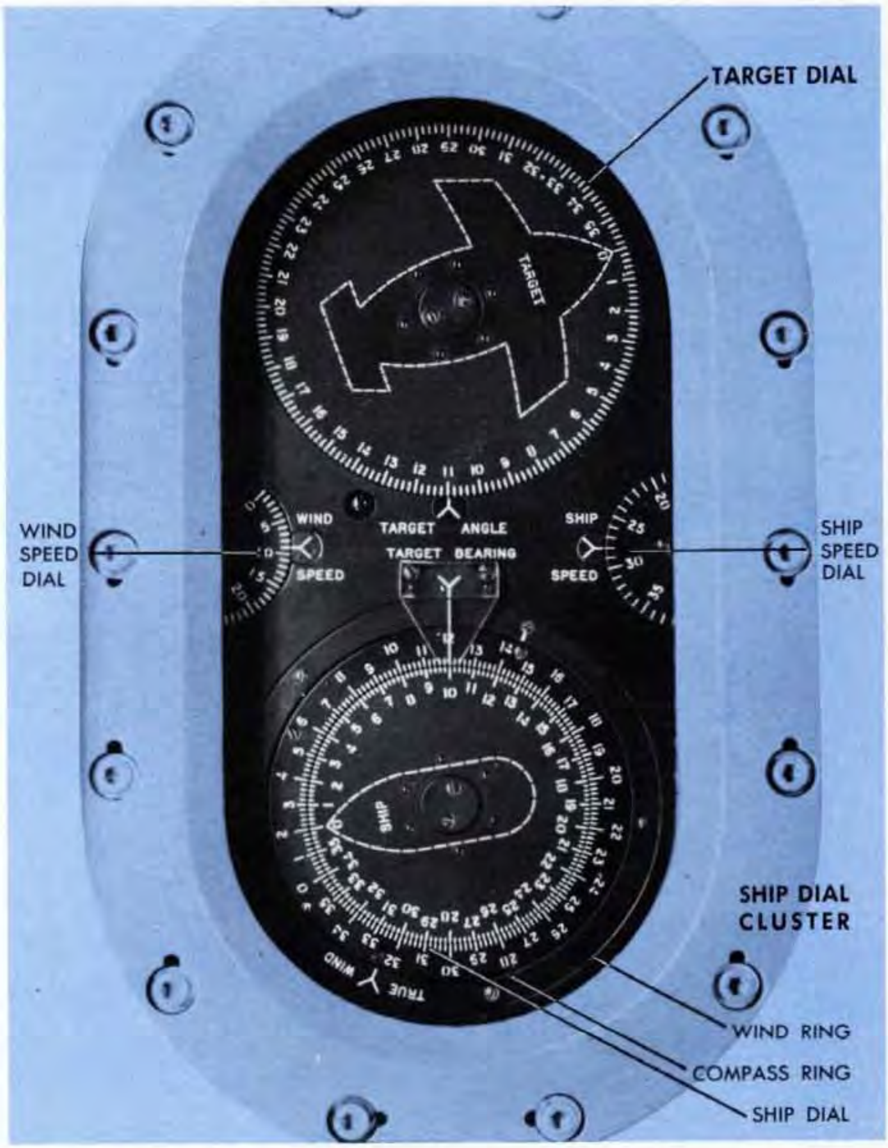
The TARGET and SHIP dial group

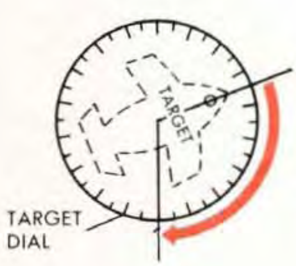


The Target and Ship Dial Group contains the Target Dial, the Ship Dial Cluster, the Wind Speed Dial, and the Ship Speed Dial.

The Target Dials and the dials in the Ship Dial Cluster indicate angles measured in the horizontal plane. A line drawn through the fixed indexes between the Target Dial and the Ship Dial Cluster represents the horizontal projection of the Line of Sight.





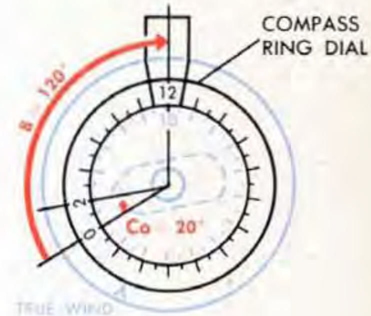


THE TARGET DIAL shows Target Angle, *A*. It is graduated every 2 degrees and numbered every 10 degrees from 0 to 360 degrees. One zero is omitted from each number to allow use of larger figures.

Target Angle is measured clockwise from the bow of the Target and is read at the fixed index representing the Line of Sight.

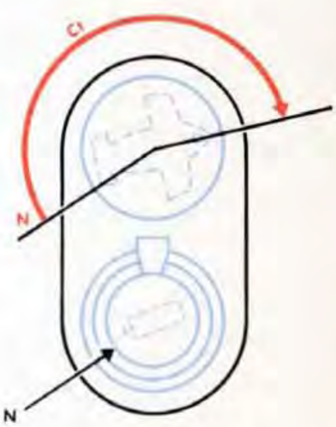
THE SHIP DIAL CLUSTER consists of three dials mounted one outside the other: the Ship Dial, the Compass Ring Dial, and the True Wind Ring Dial.

THE SHIP DIAL shows Relative Target Bearing, *Br*. *Br* is measured clockwise from the bow of the Ship and is read at the fixed index representing the Line of Sight.



THE COMPASS RING DIAL shows Ship Course, *Co*. The zero on this dial represents *North*. *Co* is measured clockwise from *North* and is read on the Compass Ring against the bow of the Ship. Changes in *Co* are recorded by movement of the Compass Dial around the Ship Dial.

The Compass Dial also shows True Target Bearing, *B*, the angle between *North* and the Line of Sight, measured clockwise from *North*. *B* is read on the Compass Ring against the fixed index. Both the Ship Dial and the Compass Ring are graduated every 2 degrees and numbered every 10 degrees from 0 to 360 degrees. The zeros are omitted to allow use of larger figures.

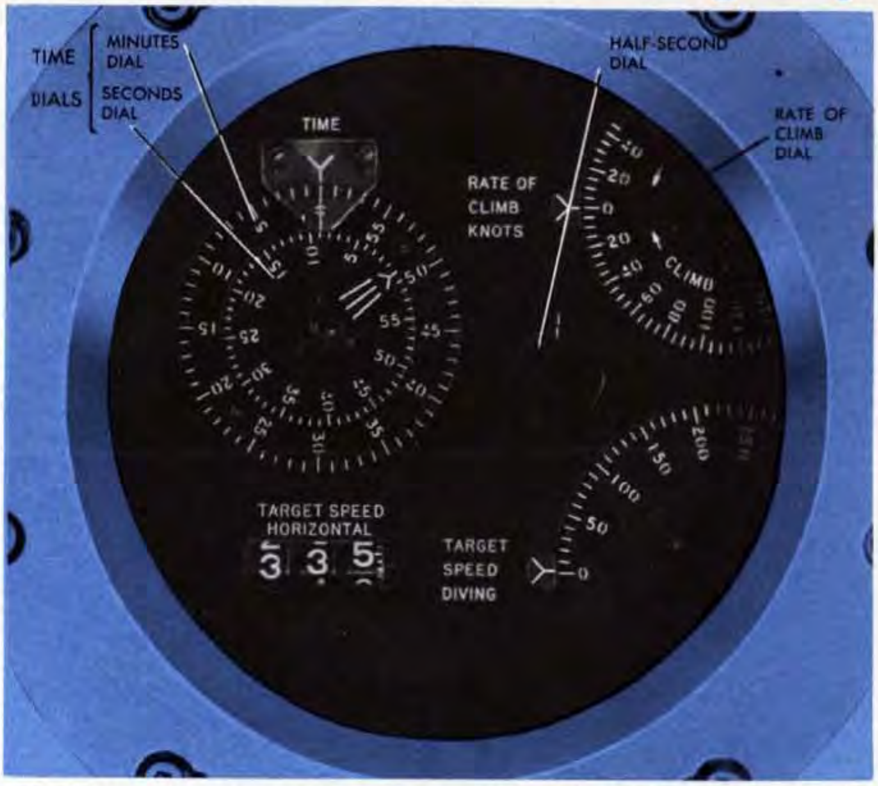


Target Course, *Ct*, is the angle measured clockwise from *North* to the bow of the Target. On the Target Dial it is possible to approximate *Ct* by observing the angle from *North*, as shown on the Compass Ring, clockwise to the bow of the Target. To obtain the exact value of *Ct*, read the value of *B* on the Compass Ring, add 180° and subtract the value of *A* as shown on the Target Dial. $Ct = B + 180° - A$.

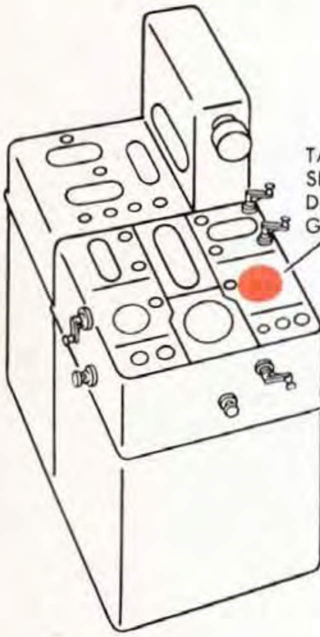
THE TRUE WIND RING DIAL has no graduations. Instead it has an index indicating the direction from which the wind is blowing. Wind Direction, *Bw*, is the angle between *North* and the direction from which the wind is blowing, measured clockwise from *North*. It is read on the Compass Ring against the True Wind Index. Wind Angle, *Bws*, is the angle between the direction from which the wind is blowing and the Line of Sight, measured clockwise on the Compass Ring from the True Wind Index to the fixed index. $Bws = B - Bw$.

The small dials on the Target and Ship Group show **WIND SPEED**, *Sw*, and **SHIP SPEED**, *So*. Each dial is read against its fixed index. The Wind Speed Dial is graduated from 0 to 60 knots, with numbers every 5 knots. The Ship Speed Dial is graduated from 0 to 45 knots, with numbers every 5 knots.

The TARGET SPEED dial group



The Target Speed Dial Group consists of the TARGET SPEED Counter, the TIME Dials, the RATE OF CLIMB Dial, and the TARGET SPEED DIVING Dial.



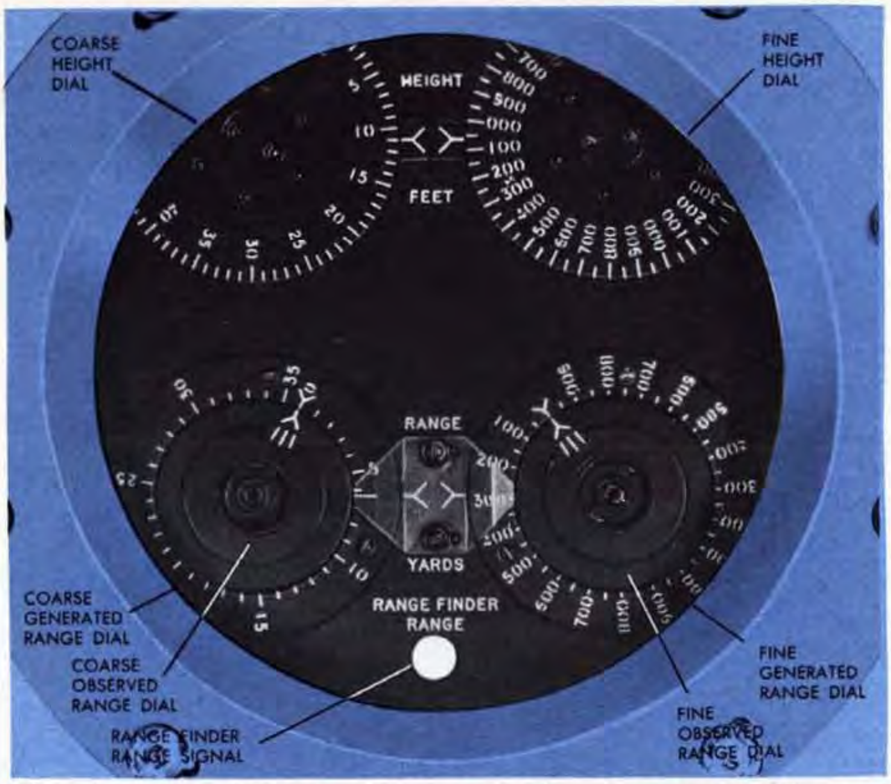
THE TARGET SPEED COUNTER shows Horizontal Ground Speed of Target, *Sh,* in knots, from 0 to 400 knots.

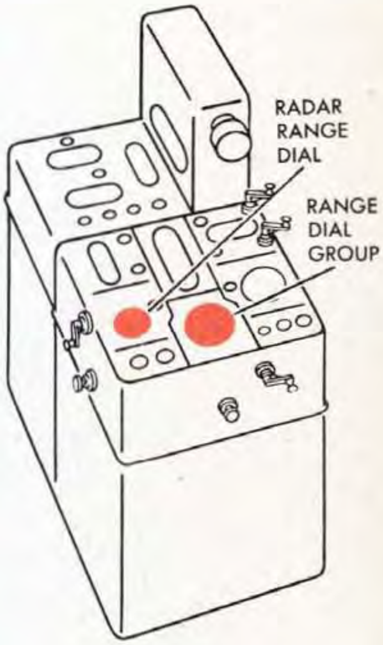
THE TIME DIALS are used principally in running tests. The ring dial is the Minutes Dial. It is graduated in minutes from 0 to 60, with numbers every 5 minutes. The inner dial is the Seconds Dial. It is graduated in seconds from 0 to 60, with numbers every 5 seconds. Both dials are read against the fixed index. The small dial is the Half-second Dial. It has one graduation and makes one revolution every half-second.

THE RATE OF CLIMB DIAL shows Rate of Climb, *dH,* in knots. It is graduated every 5 knots and numbered every 20 knots from 0 to CLIMB (plus) 150 knots, and from 0 to DIVE (minus) 250 knots.

THE TARGET SPEED DIVING DIAL is used only during certain dive attacks against Own Ship. It shows a substitute Range Rate, *dR,* for use when a special dive attack setup is ordered. This dial turns from minus 450 to plus 450 knots. It is graduated every 10 knots, numbered every 50 knots, and is read against the fixed index. To avoid confusion, only the DIVE (minus) side is graduated and numbered.

The RANGE dial group





The Range Dial Group contains the Generated and Observed Range Dials and the Height Dials. The coarse dials are on the left, and the fine dials are on the right.

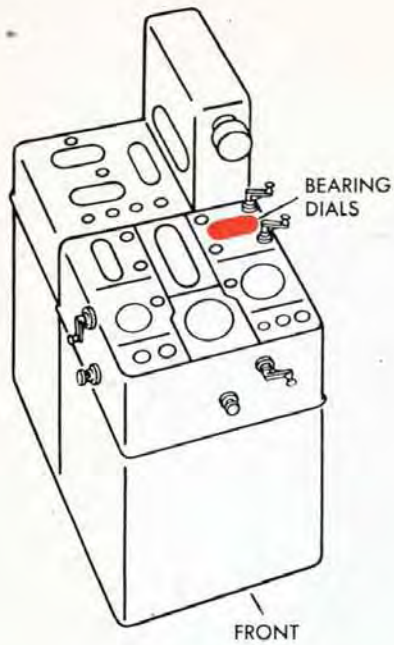
GENERATED RANGE, *cR*, is shown on two ring dials, coarse and fine. The coarse *cR* Dial is graduated every 1,000 and numbered every 5,000 yards up to 35,000. Each dial has an index at its zero. The fine *cR* Dial is graduated every 50 and numbered every 100 yards. One revolution of the fine dial represents 2,000 yards. Each *cR* Dial is read against its fixed index.

OBSERVED RANGE, *R*, is indicated on two inner dials, coarse and fine. These inner dials have no graduations. When the indexes of the outer, *cR*, Range Dials are matched with the indexes on the inner, *R*, Range Dials, *R* equals *cR*. *R* can then be read indirectly by reading *cR* against the fixed index.

THE RANGE FINDER RANGE SIGNAL is in front of the Range Dials. A white signal appears here when the Range Operator in the Director presses his key to signal that Observed Range is correct. Otherwise this signal is black.

THE HEIGHT DIALS show the vertical height, *H*, of the Target. The coarse dial at the left is graduated every 1,000 feet and numbered every 5,000 feet up to 50,000. The fine dial is graduated every 50 feet and numbered every 100 feet. The Height Dials are read at their fixed indexes.

THE RADAR RANGE DIAL shows Radar Range. This dial is used chiefly to let the Range Operator follow the Radar tracking of a target before it comes within the operating limits of the Computer Tracking Section. The Radar Range Dial is graduated and numbered every 5,000 yards from 0 to 100,000 yards, and is read at the fixed index.



The BEARING dials

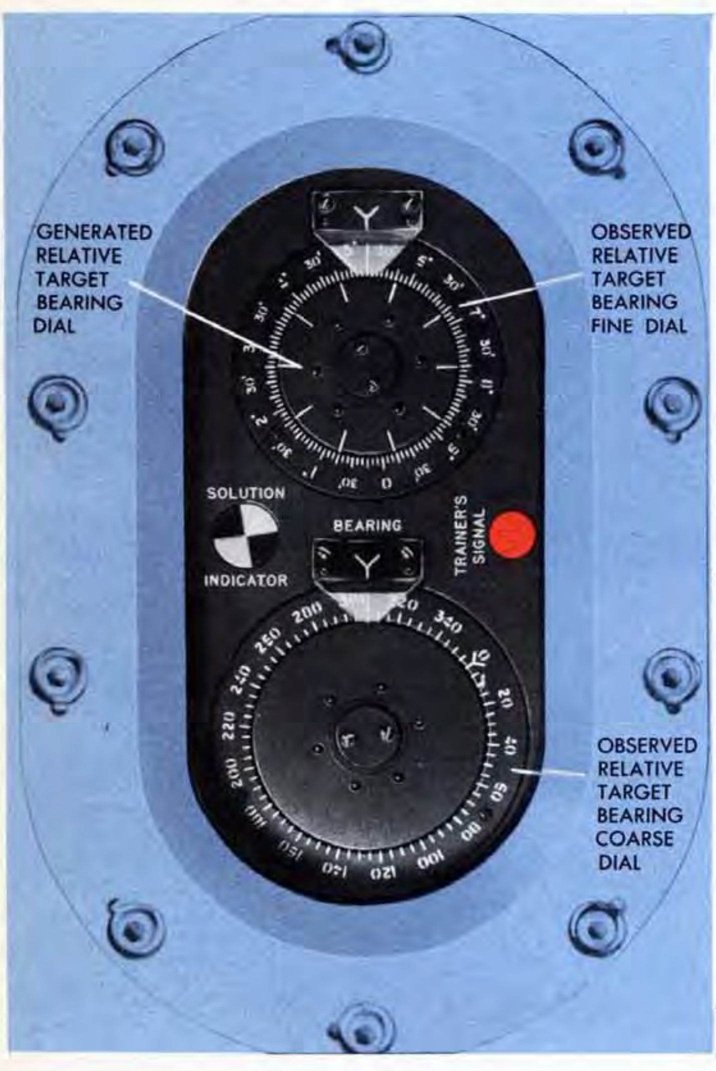
The Bearing Dials consist of a fine and a coarse ring dial, and an inner fine dial.

OBSERVED RELATIVE TARGET BEARING, *Br*, is shown on the two ring dials. Notice that the arrangement of the Bearing Dials is opposite to that of the Range Dials. In the Bearing Dial Group, the observed value is shown on the two *outer* dials. Generated Changes of Relative Target Bearing, $\triangle cBr$, turn only the fine *inner* dial.

The coarse ring dial is graduated every 5 degrees and numbered every 20 degrees from 0 to 360 degrees.

The fine ring dial is graduated every 5 minutes and numbered every 30 minutes. One revolution represents 10 degrees.

Both ring dials are read at their fixed indexes.



THE GENERATED BEARING DIAL is not numbered but has ten equally spaced graduations. These graduations are used to show whether Generated Bearing is changing at the same RATE as Observed Bearing. When the inner and outer fine dials turn together, the Generated Bearing Rate is correct. The position of these graduations relative to the ring dial is immaterial.

THE TRAINER'S SIGNAL shows red when the Trainer in the Director has his signal key closed. Otherwise the signal is black.

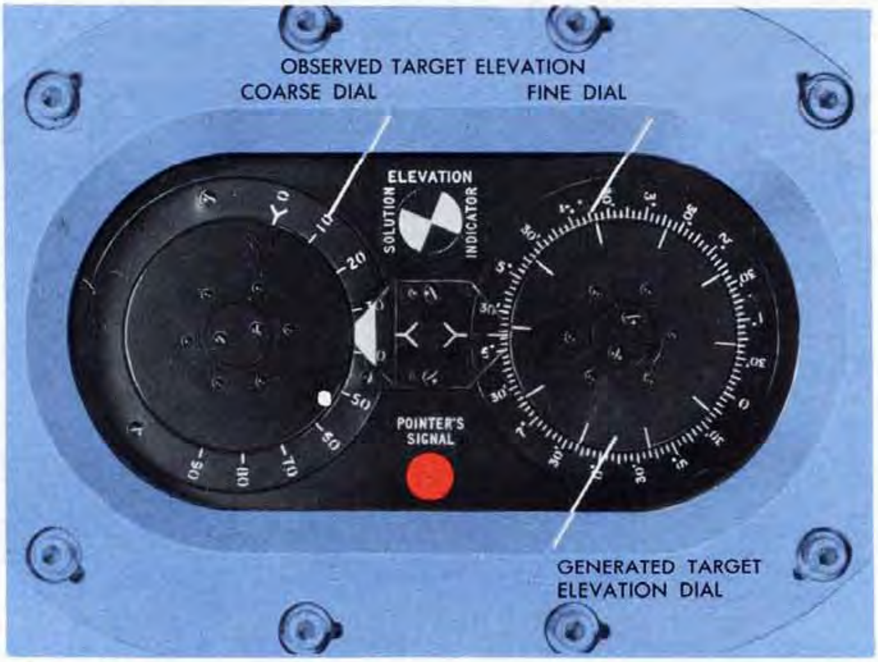
THE SOLUTION INDICATOR operates in Automatic Control only. It revolves when the Trainer in the Director is turning his handwheels.

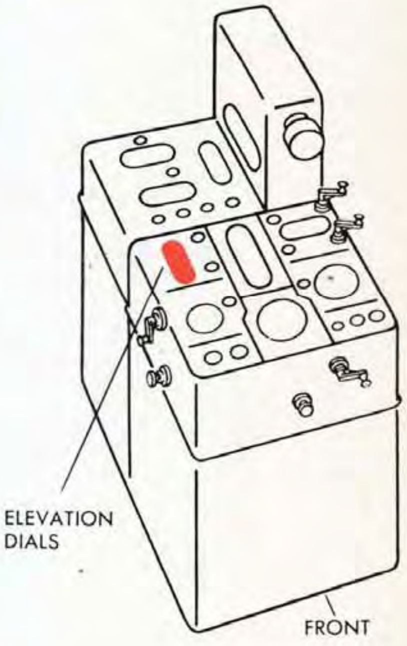
If the Trainer's Signal shows red while the Solution Indicator turns, Bearing Rate Corrections are being put into the Rate Control Computing Mechanism automatically.

The ELEVATION dials

The Elevation Dials, like the Bearing Dials, consist of a fine and a coarse ring dial and a fine inner dial.

OBSERVED TARGET ELEVATION, *E* is shown on the two outer ring dials. Generated Changes of Target Elevation, $\triangle cE$, turn the fine inner dial.





The coarse ring dial is graduated and numbered every 10 degrees, from 0 to 90 degrees.

The fine ring dial is graduated every 5 minutes and numbered every 30 minutes. One revolution of this dial represents 10 degrees.

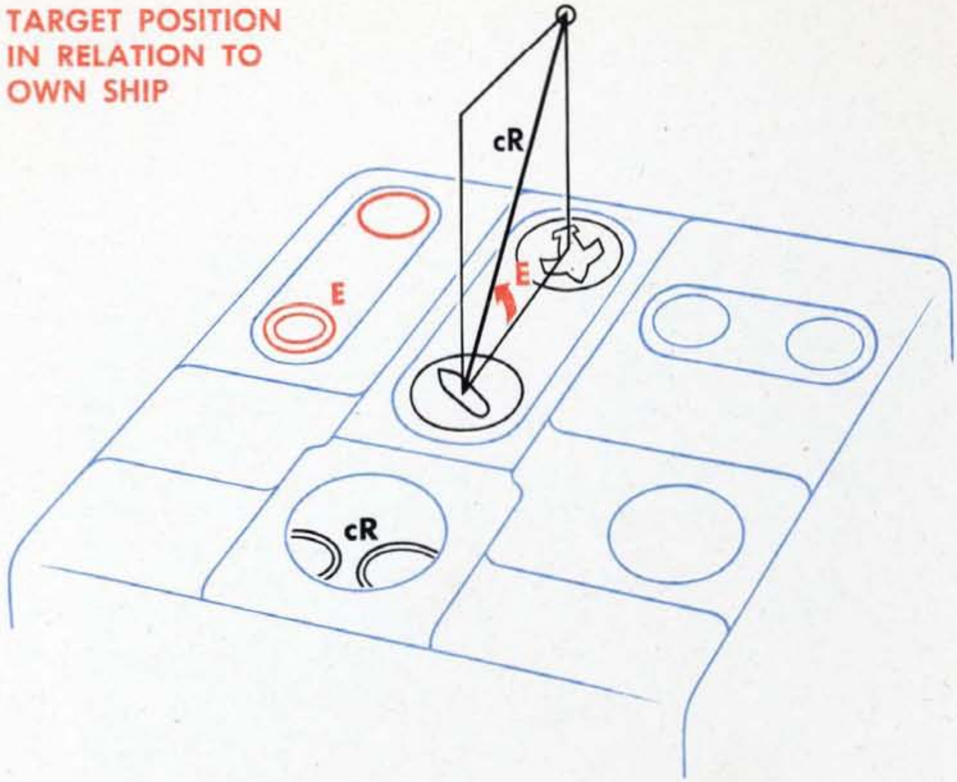
Both ring dials are read at their fixed indexes.

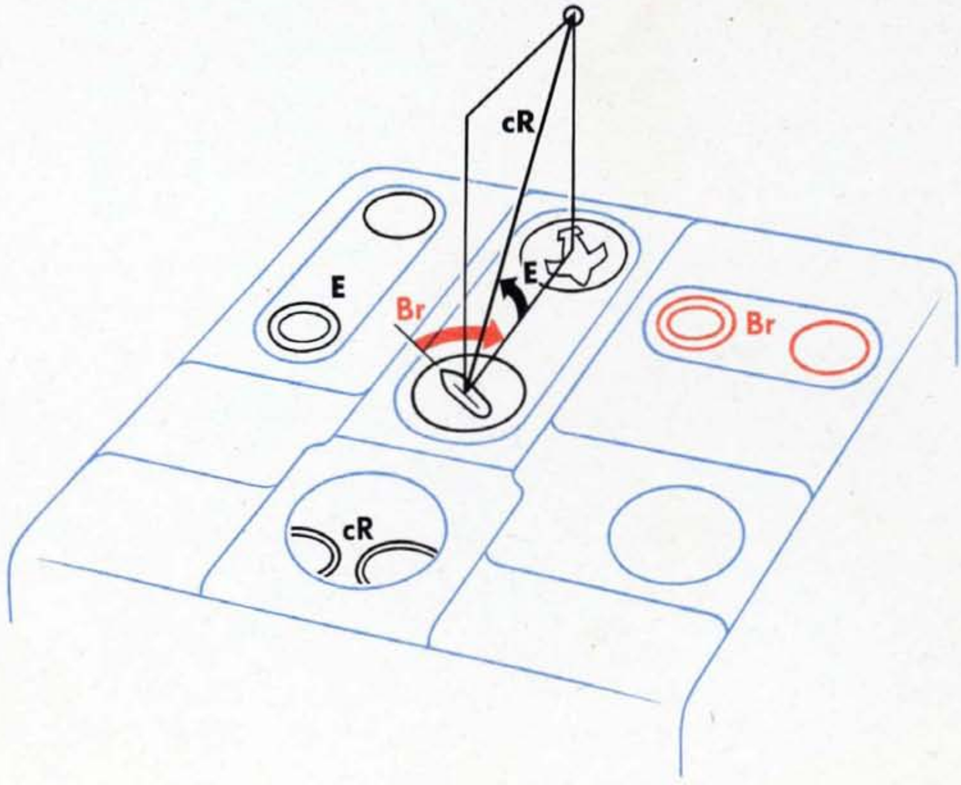
THE GENERATED ELEVATION DIAL has ten equally spaced graduations which are used to show whether Generated and Observed Elevation are changing at the same rate. The position of these graduations relative to the ring dial is immaterial.

THE POINTER'S SIGNAL AND THE SOLUTION INDICATOR in the Elevation Dial Group work in exactly the same way as those in the Bearing Group.

The Pointer's Signal is red when the Pointer in the Director closes his key. Otherwise the signal is black. When the signal is red and the Solution Indicator turns, Elevation Rate Corrections are being put into the Rate Control Computing Mechanism automatically.

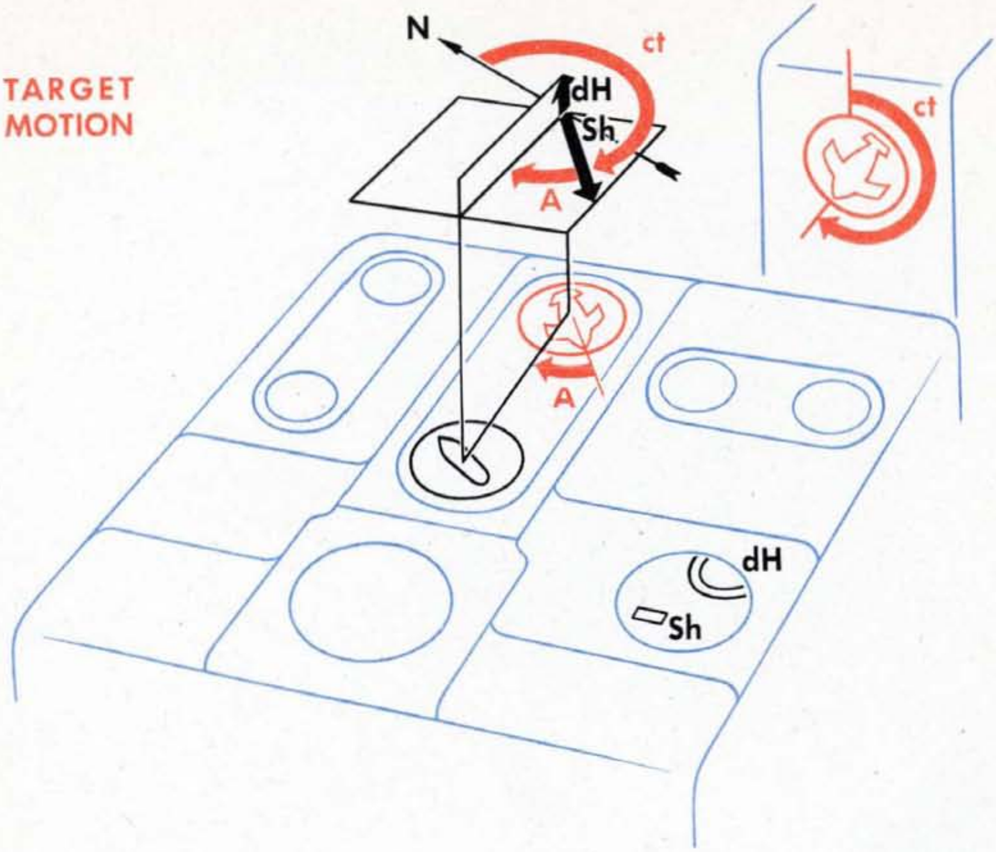
How the DIALS picture the



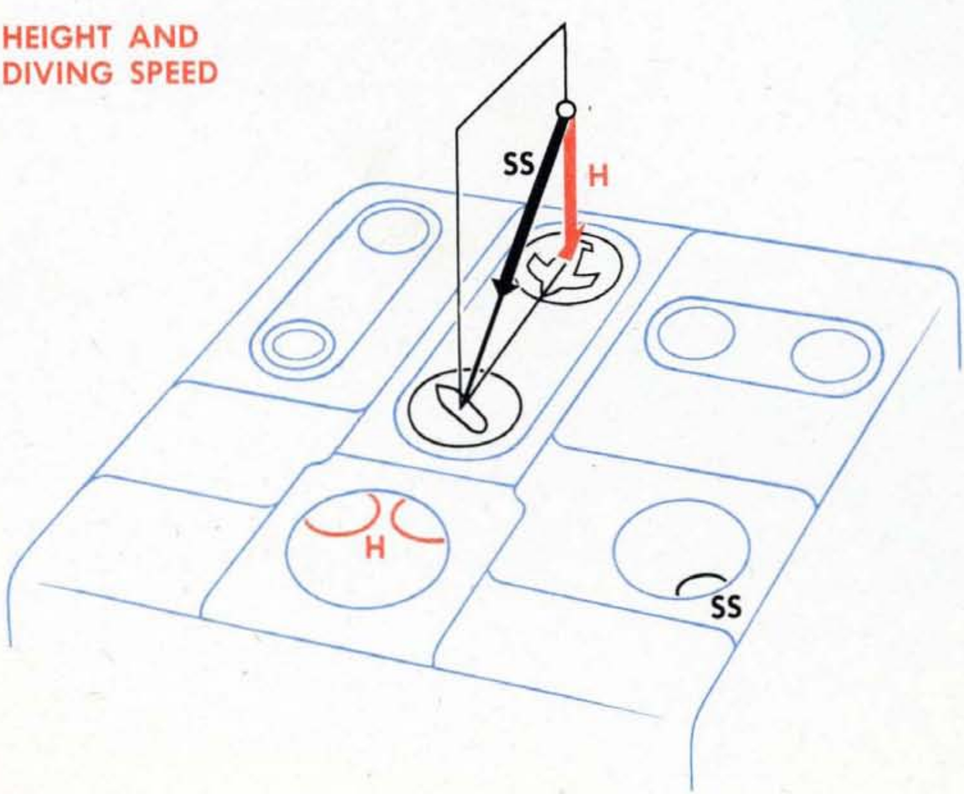


FIRE CONTROL PROBLEM

TARGET MOTION

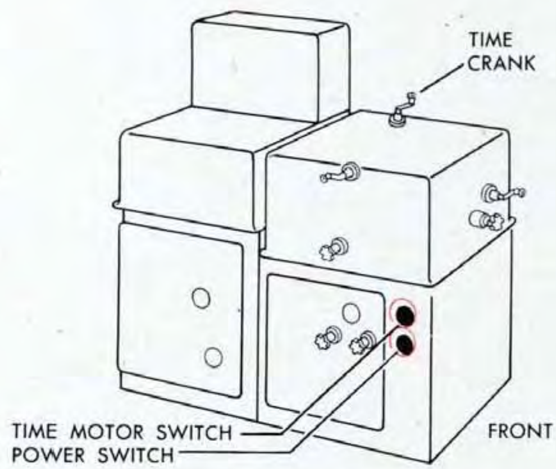


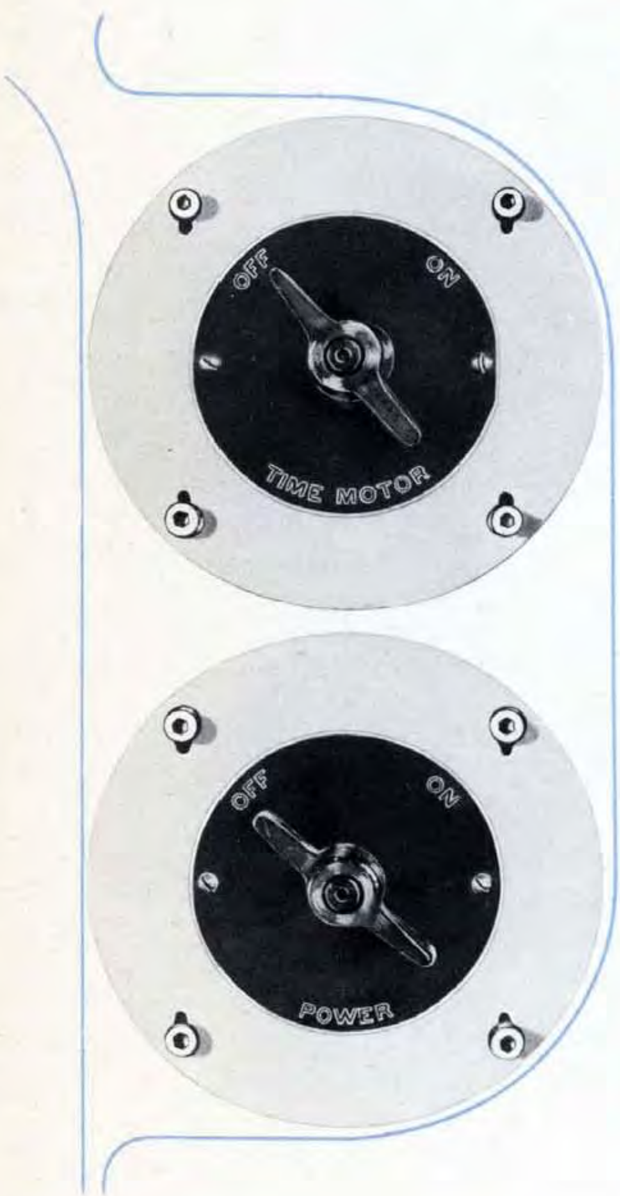
HEIGHT AND DIVING SPEED



The TIME MOTOR and POWER switches

The Time Motor and Power Switches are located on the lower left side of the Computer near the front. The station from which these switches are operated depends on ship's doctrine.





The TIME MOTOR SWITCH is the upper of the two switches. It has two positions: OFF and ON. Turning this switch to the ON position puts the Time Motor in operation when the Power Switch is ON.

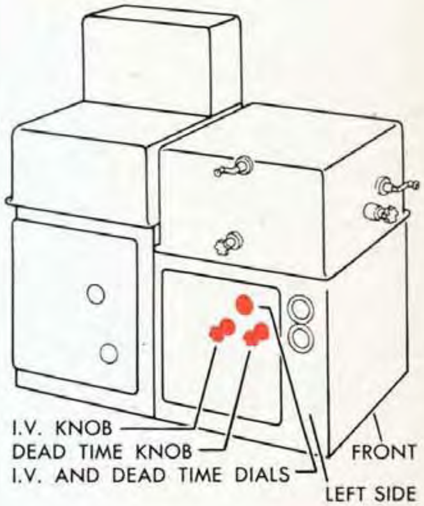
NOTE:
In the event that the Time Motor does not start, pull the Time Crank OUT and turn it clockwise.

The POWER SWITCH is the lower of the two switches. It has two positions: OFF and ON. Turning it to the ON position energizes the Computer.

CAUTION:
The Power Switch should be ON before any operating handcranks are turned.

INITIAL VELOCITY and DEAD TIME

The Initial Velocity and Dead Time Dials and Knobs are on the lower left side of the Computer, near the front and to the left of the Time Motor and Power Switches. The station from which these controls are operated depends on ship's doctrine.



The INITIAL VELOCITY DIAL shows Initial Velocity, *I.V.*, in feet per second. It is graduated every 5 feet per second and numbered every 50 feet per second from 2350 to 2600 feet per second. Making a setting of this dial puts into the Computer a correction for the difference between the *I.V.* which is ordered and 2550 feet per second. The *I.V.* shaft line is positioned by the Initial Velocity Knob.

The DEAD TIME DIAL shows Dead Time, Tg, the time in seconds between the setting of the fuze and the firing of the projectile. The dial is graduated from 0 to 6 seconds at half-second intervals. The Tg shaft line is positioned by the Dead Time Knob.

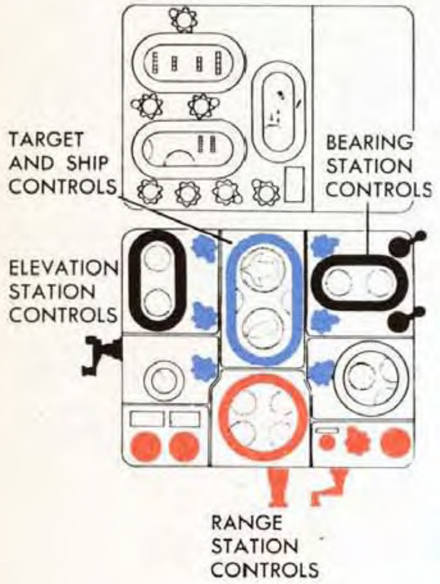
The INITIAL VELOCITY and DEAD TIME KNOBS each have two positions: IN and OUT. A pin holds each knob in the IN position. To make a setting to the dial, the pin must be lifted and the knob pulled OUT. When the knobs are released they spring back to their IN positions.

NOTE:

Set the Initial Velocity Dial at the computed Initial Velocity of the projectiles. For example, if the Initial Velocity for a given battery is determined to be 2590 feet per second, turn the Initial Velocity Knob until the Initial Velocity Dial reads 2590 at the fixed index.

Set the Initial Velocity Dial at 2550 only when the projectiles actually have this Initial Velocity, or when running tests and making settings which require Initial Velocity to be at this value.

THE CONTROLS ON THE FRONT OF THE COMPUTER MARK 1



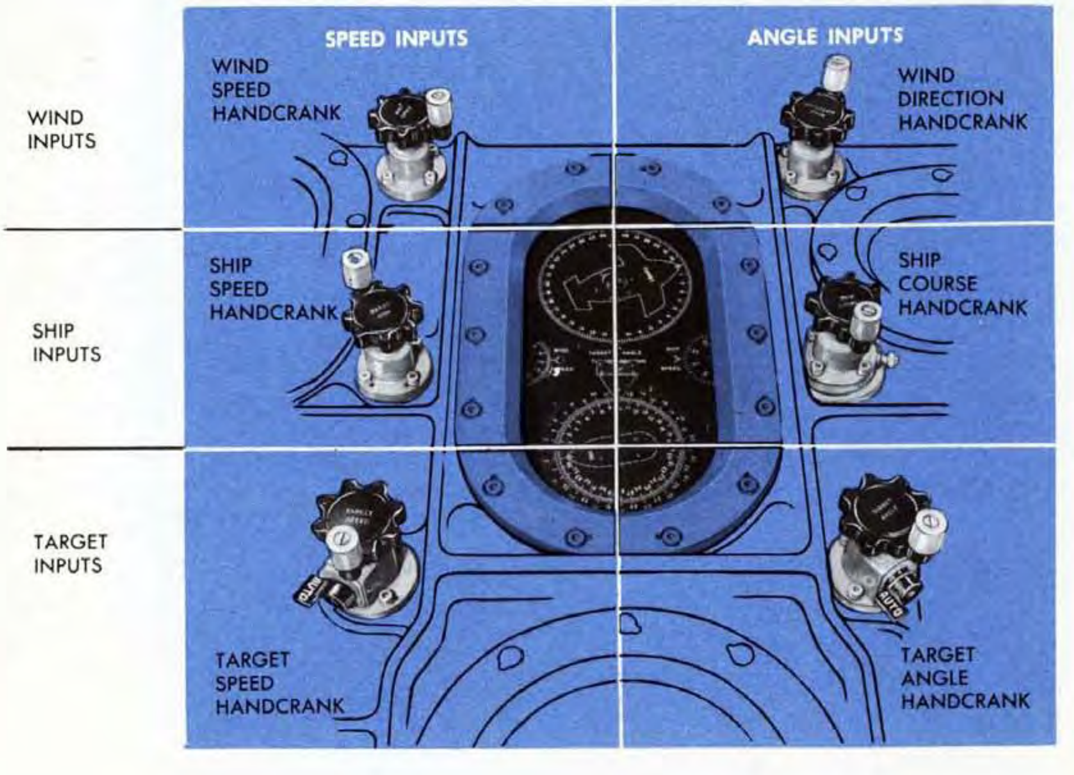
The simplest way to become familiar with the controls on the front of the Computer is to group them by operating stations.

The controls fall into four groups: the Target and Ship Dial Group Controls, the Range Station Controls, the Bearing Station Controls, and the Elevation Station Controls.

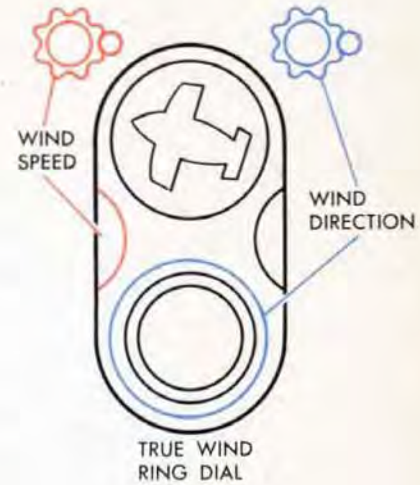
Operation of the controls in the Target and Ship Dial Group is divided among the operating stations according to ship's doctrine.

The controls in the target and ship group

There are six handcranks in this group. The three handcranks to the left of the dials are for SPEED INPUTS. Those on the right are for ANGLE INPUTS.



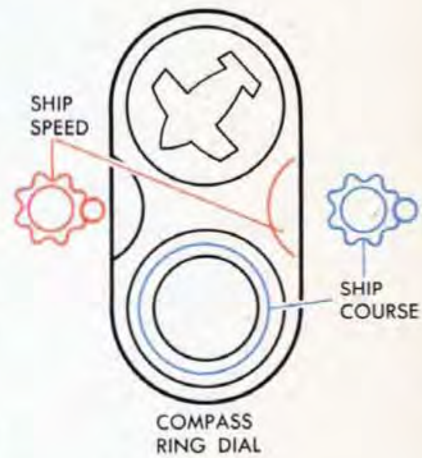
THE WIND SPEED HANDCRANK puts in values of Wind Speed, *Sw*, which show on the Wind Speed Dial.



THE WIND DIRECTION HANDCRANK puts in values of Wind Direction, *Bw*, which are read on the Wind Ring Dial.

Wind Speed and Wind Direction are always put in by hand, as ordered.

THE SHIP SPEED HANDCRANK has two positions: IN and OUT, with a pin to hold it in either position. When this handcrank is in the IN position, it puts in values of Ship Speed, *So*, which are read on the *So* Dial. When this handcrank is in the OUT position, the *So* Line and Dial are positioned automatically from the Pitometer Log through the Ship Speed Receiver.

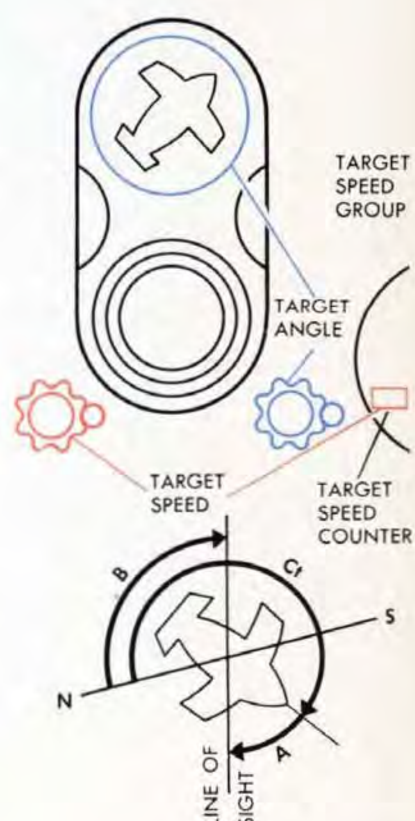


When setting the Ship Speed Dial by hand, it is important to remember that 0 and 45 are at the same position on this dial.

When Ship Speed is received by synchro transmission from the Pitometer Log, it is possible for the single-speed Ship Speed Receiver to be out of synchronism with the incoming signal. If the correct value does not appear on the dial, push the handcrank IN, set the dial by hand, and pull the handcrank OUT.

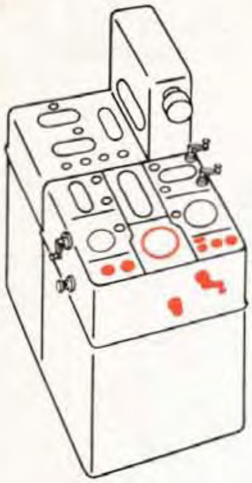
THE SHIP COURSE HANDCRANK has two positions: IN and OUT, with a pin to hold it in either position. When this handcrank is in the IN position, it puts in values of Ship Course, *Co*, which are read on the Compass Ring Dial. When this handcrank is in the OUT position, the *Co* Line and Dial are positioned automatically by the double-speed Ship Course Receiver which receives *Co* from the Gyro Compass.

THE TARGET SPEED HANDCRANK puts in Target Horizontal Ground Speed, *Sh*, which shows on the Target Speed Counter in the Target Speed Dial Group.



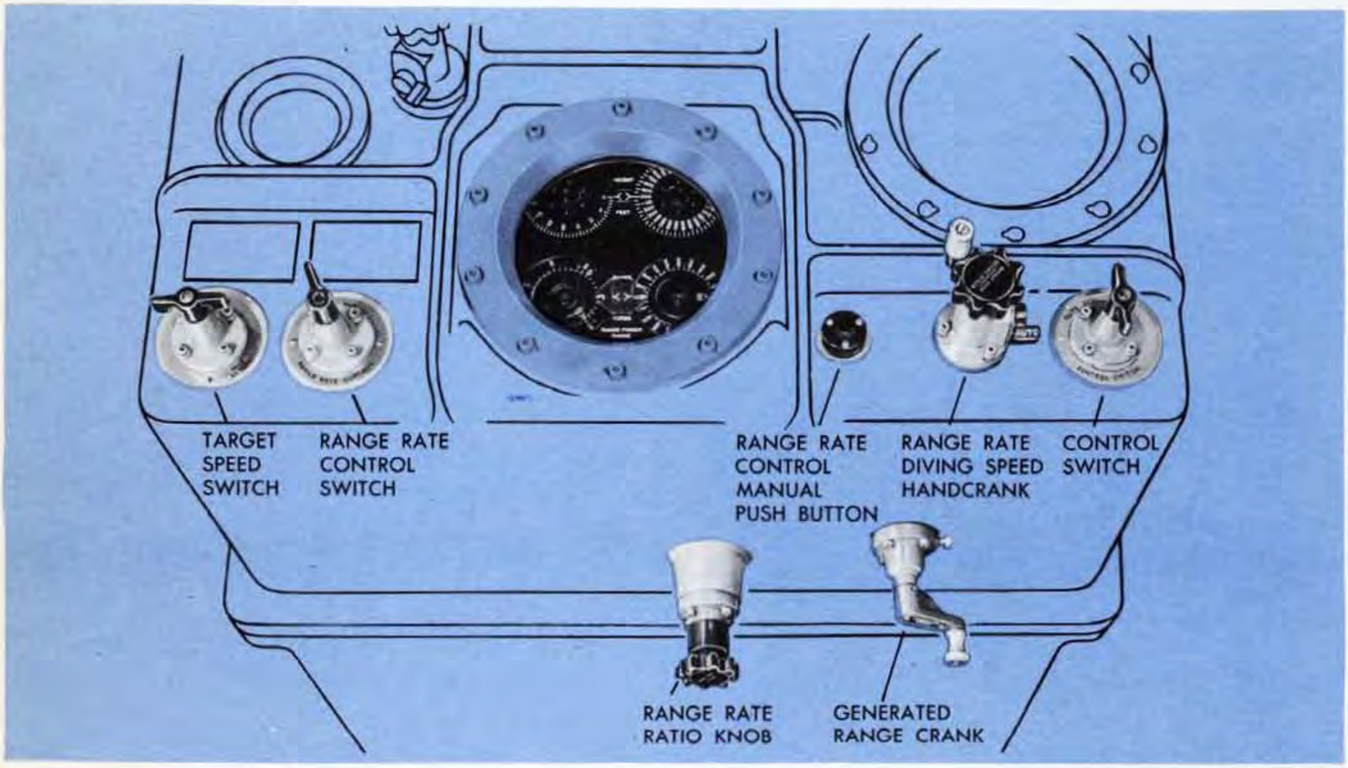
THE TARGET ANGLE HANDCRANK positions the Target Course, *Ct*, shaft line and the Target Course Indicator Dial. *Ct* is subtracted from True Bearing, *B*, in the Computer, producing Target Angle, *A*, which appears on the Target Dial. $A = 180° + B - Ct$.

The Target Speed and Target Angle Handcranks have two positions: HAND and AUTO. Shift levers move them from one position to the other. With the levers at HAND position, these handcranks are connected to their shaft lines. With the levers at AUTO, the handcranks are disconnected, and the *Sh* and *Ct* shaft lines are positioned by the Rate Control Mechanism.



The controls at the range station

In addition to the dials, the controls at the Range Station include three switches: the Control Switch, the Range Rate Control Switch, and the Target Speed Switch. The controls also include the Generated Range Crank, the Range Rate Ratio Knob, the Range Rate/Diving Speed Handcrank, and the Range Rate Control Manual Push Button.

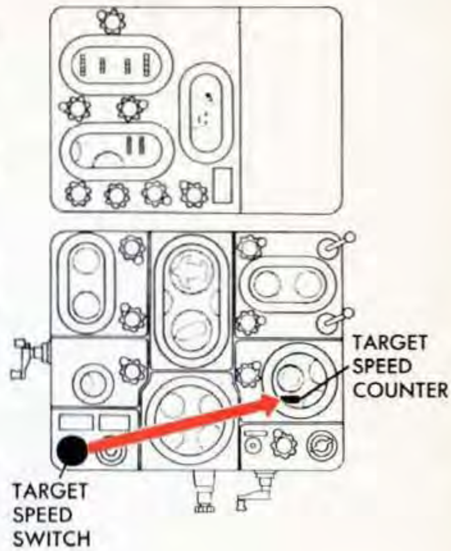


THE CONTROL SWITCH is on the right side of the top of the Computer near the front. This switch determines the method of rate-controlling Bearing and Elevation. The Control Switch has three positions: AUTO, SEMI-AUTO, and LOCAL.

With the Control Switch at AUTO, Bearing and Elevation Corrections are made automatically on signal from the Trainer and Pointer in the Director.

With the Control Switch at SEMI-AUTO, Bearing and Elevation Corrections are put into the Computer by the Computer Crew.

With the Control Switch at LOCAL, the Rate Control Mechanism is inoperative. This type of operation is used against surface targets when the Director is not operating.



THE TARGET SPEED SWITCH is connected to the Target Speed, *Sh,* Servo Motor. This switch has three positions: NORMAL, INCREASE, and DIVE ATTACK.

When the Target Speed Switch is at NORMAL, the *Sh* Follow-up controls the *Sh* Motor. This allows normal operation of the Rate Control Mechanism.

When the Target Speed Switch is at INCREASE, the "increase" side of the *Sh* Servo Motor is energized. This causes the *Sh* shaft line and counter to turn rapidly in an increasing direction. The switch has to be held at INCREASE since it springs back to NORMAL when released.

When the Target Speed Switch is at DIVE ATTACK, the "decrease" side of the *Sh* Servo Motor is energized. This causes the value on the Target Speed shaft line to decrease rapidly, running the Target Speed counter to zero. The switch stays at DIVE ATTACK until moved to another position.

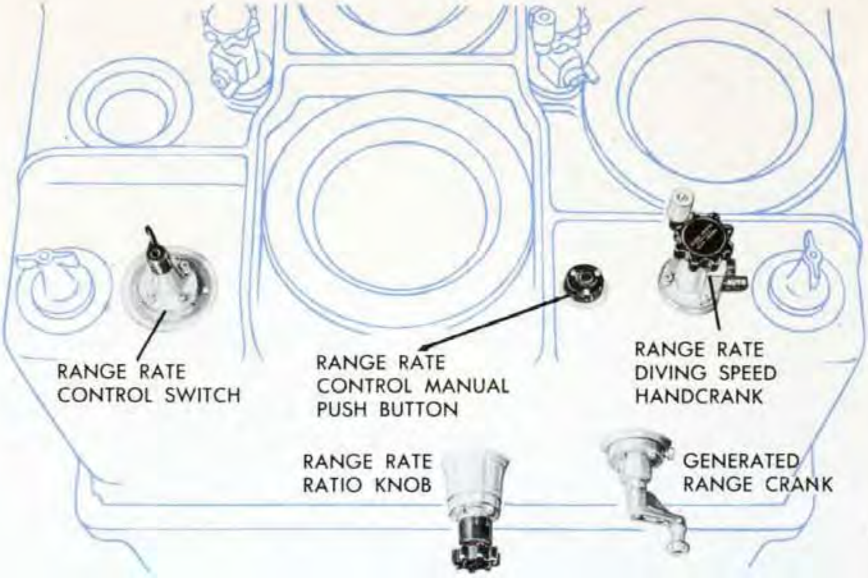
The Target Speed Switch functions only when the Target Speed and Target Angle Handcranks are at AUTO.

THE RANGE RATE CONTROL SWITCH is at the left side of the Computer, near the front. It has a one-wing handle. This switch controls the method by which Range Rate Corrections are put into the Rate Control Mechanism. The switch has two positions: AUTO and MANUAL.

With the Range Rate Control Switch at AUTO, Range and Range Rate Corrections are put in automatically on signal from the Range Operator in the Director or the Radar Operator.

With the Range Rate Control Switch at MANUAL, these corrections are put in bv a member of the Computer Crew.

The position of the Range Rate Control Switch is independent of the position of the Control Switch. RANGE MAY BE RATE-CONTROLLED EITHER AUTOMATICALLY OR SEMI-AUTOMATICALLY DURING AUTOMATIC OR SEMI-AUTOMATIC RATE CONTROL OF ELEVATION AND BEARING.

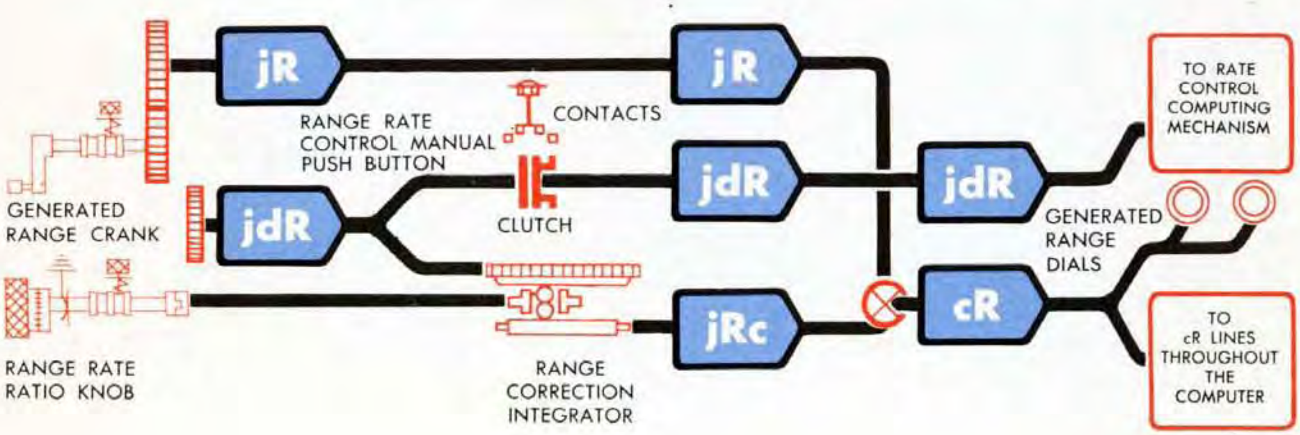


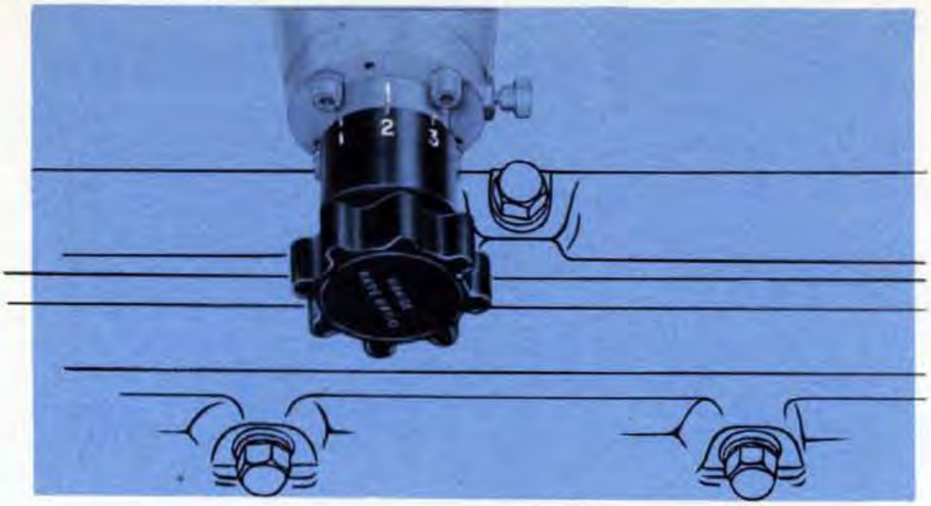
THE GENERATED RANGE CRANK turns the Generated Range line. It has two positions, IN and OUT, with a pin to hold it in the OUT position.

When the Range Rate Control Switch is at AUTO, Range Rate Control is handled automatically on signal from the Range Operator in the Director. The Generated Range Crank must be in its OUT position.

When the Range Rate Control Switch is at MANUAL, Range Rate Control is handled through the Generated Range Crank. In its OUT position the crank puts in linear Range Correction, *jR*, to match the indexes on the Generated Range Dials to the indexes on the Observed Range Dials. In its IN position the Generated Range Crank can make two kinds of corrections. It puts in linear Range Correction, *jRc*, to match *cR* to *R*, and if the Range Rate Control Manual Push Button is depressed, it also puts Range Rate Correction, *jdR*, into the Rate Control Computing Mechanism.

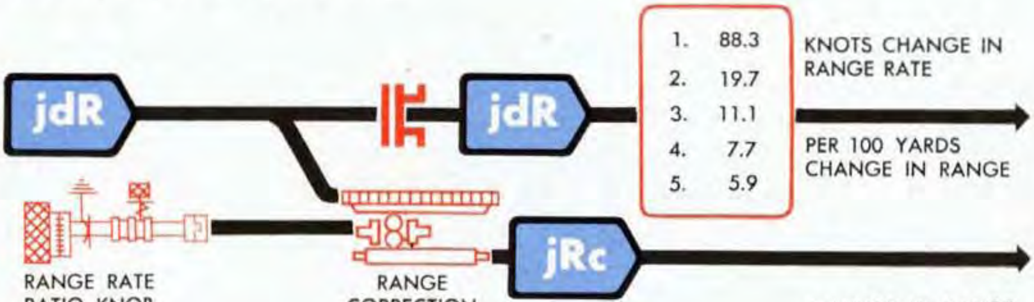
THE RANGE RATE CONTROL MANUAL PUSH BUTTON is located above the Generated Range Crank. When the Range Rate Control Switch is at MANUAL, pressing this push button closes a solenoid clutch which allows Range Rate Corrections to drive into the Rate Control Computing Mechanism.





THE RANGE RATE RATIO KNOB positions the carriage of the Range Correction Integrator. This integrator controls the ratio between linear Range Correction and the Range Rate Correction put into the Rate Control Computing Mechanism during Range Rate Control.

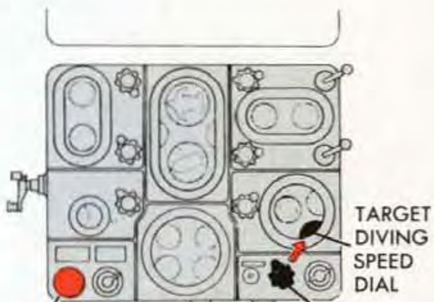
The sleeve of the Range Rate Ratio Knob is calibrated from 1 to 5. The largest Range Rate Correction for each linear Range Correction is made with the knob set at 1. As the knob is turned toward 5, the Range Rate Correction for each linear Range Correction becomes smaller. With the knob set at 1, a few revolutions of the Generated Range line will put in a large amount of Range Rate Correction. With the knob set at 5, an equal number of revolutions of the line results in a much smaller amount of Rate Correction.



The Range Rate Ratio Knob has two positions: IN and OUT. It is always operated in the IN position. The OUT position is provided only to permit removal of the cover of the Computer for adjustment or repair.

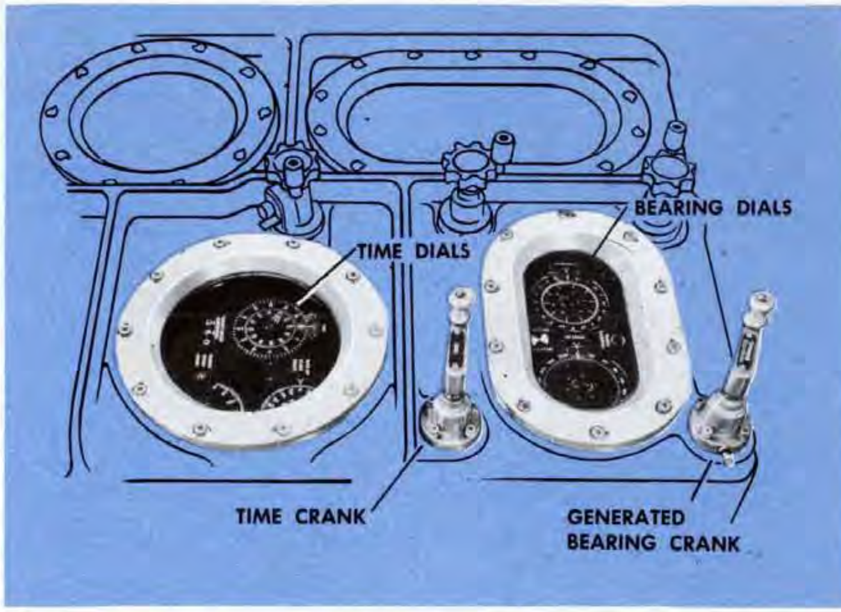
The RANGE RATE DIVING SPEED HANDCRANK has two positions: HAND and AUTO. At HAND it positions the Target Diving Speed Dial and the *dR* shaft line .When this handcrank is at AUTO, it is disengaged, and the *dR* shaft line is positioned automatically by *dR* from the Relative Motion Group.

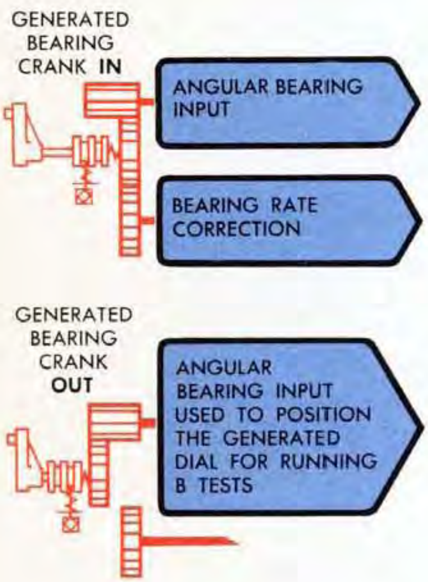
The Range Rate/Diving Speed Handcrank is used only when a DIVE ATTACK order is given and when the Target Speed Switch is at DIVE ATTACK. This handcrank must never be used when the Target is diving at other ships.



The controls at the bearing station

The controls at the Bearing Station consist of the Generated Bearing Crank and the Time Crank.





THE GENERATED BEARING CRANK has two positions: IN and OUT, with a pin to hold it in the OUT position.

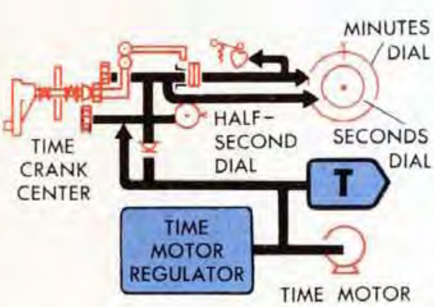
In Automatic Control, Bearing Rate Control is handled automatically on signal from the Trainer in the Director. The Generated Bearing Crank must be in its OUT position.

In Semi-automatic Control, the Generated Bearing Crank is put in its IN position to make Bearing Rate Control Corrections.

In its IN position, the Generated Bearing Crank puts in both angular inputs to Generated Bearing and *Bearing Rate Corrections* to keep the Generated Bearing Dial rotating at the same speed and in the same direction as the Observed Bearing Dial.

In its OUT position, the crank can be used to position the Generated Bearing Dial for running B Tests.

In Local Control, the Generated Bearing Crank in its OUT position is used to set the Relative Target Bearing Ring Dials to read the initial value of Generated Relative Target Bearing. Subsequent corrections to Generated Relative Target Bearing can also be introduced with this crank.

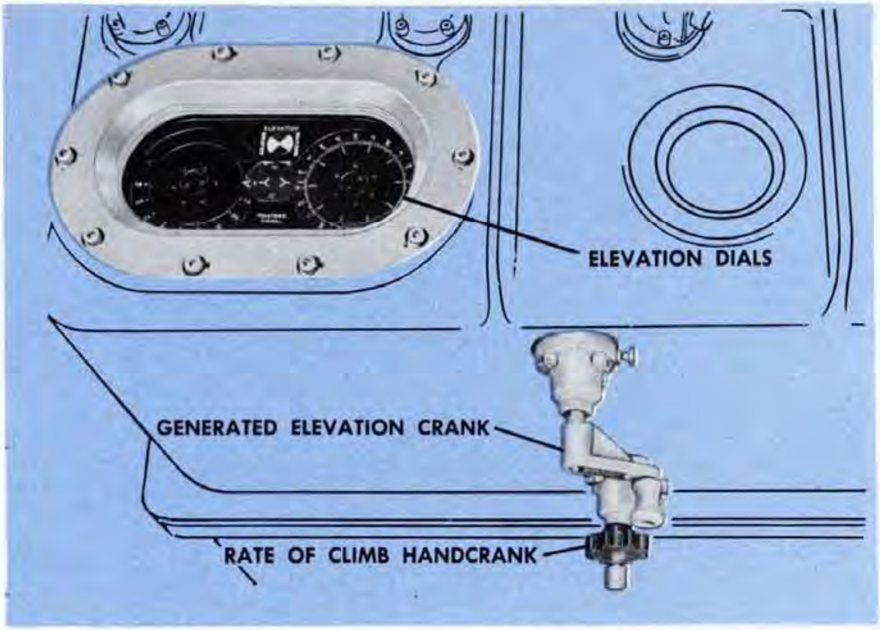


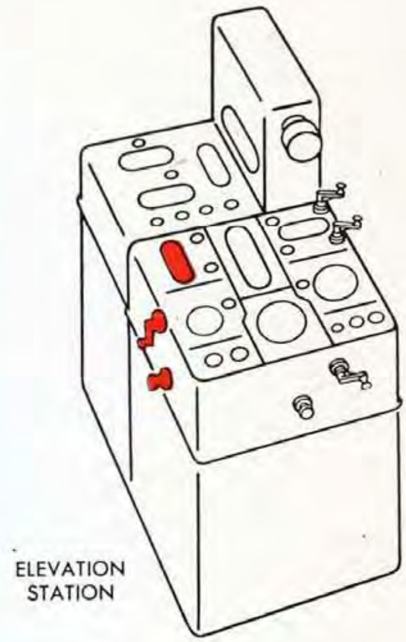
THE TIME CRANK has three positions: IN, CENTER, and OUT. It has to be held in the IN or OUT position, since it springs to CENTER when released. It is normally in the CENTER position, allowing the Time shaft line and dials to be positioned by the Time Motor. When the Time Crank is pushed IN, it zeros the Minute ring of the Time Dials. When turned in the IN position, this crank turns the Seconds Dial.

In its OUT position, the Time Crank is connected to the Time shafting. With the Time Motor Switch OFF, the Time shaft line may be rotated by the Time Crank for test purposes.

The controls at the elevation station

The controls at the Elevation Station consist of the Generated Elevation Crank and the Rate of Climb Handcrank.





THE GENERATED ELEVATION CRANK has two positions: IN and OUT, with a pin to hold it in the OUT position.

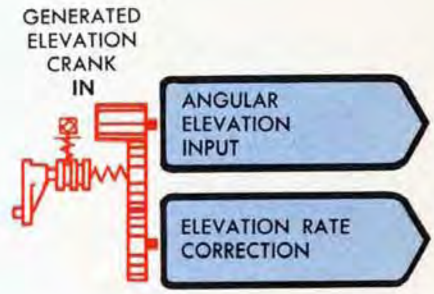
In Automatic Control, Elevation Rate Control is handled automatically on signal from the Pointer in the Director. The Generated Elevation Crank must be in its OUT position.

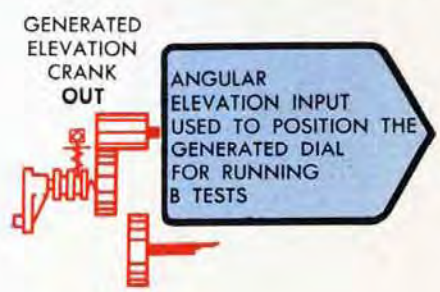
In Semi-automatic Control, Elevation Rate Control Corrections are put in through the Generated Elevation Crank. The Generated Elevation Crank must be in its IN position.

In its IN position the Generated Elevation Crank puts in both angular inputs to Generated Elevation and Elevation Rate Corrections, to keep the Generated Elevation Dial rotating at the same speed and in the same direction as the Observed Elevation Dial.

In its OUT position the crank can be used to position the Generated Elevation Dial for running B Tests.

In Local Control, the Generated Elevation Crank is pulled OUT, since it is not used.

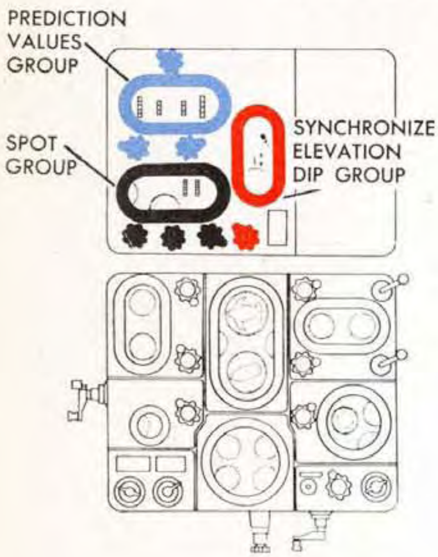




THE RATE OF CLIMB HANDCRANK is located below the Generated Elevation Crank. It has two positions: IN and OUT. In its IN position, it sets values of Rate of Climb, *dH*, into the Rate of Climb shaft line. The value on this shaft line can be read on the Rate of Climb Dial in the Target Speed Group.

When the Rate of Climb Handcrank is OUT, it is disconnected and the Rate Control Mechanism positions the *dH* shaft line automatically.

HANDCRANKS and DIALS on the REAR TOP of the COMPUTER

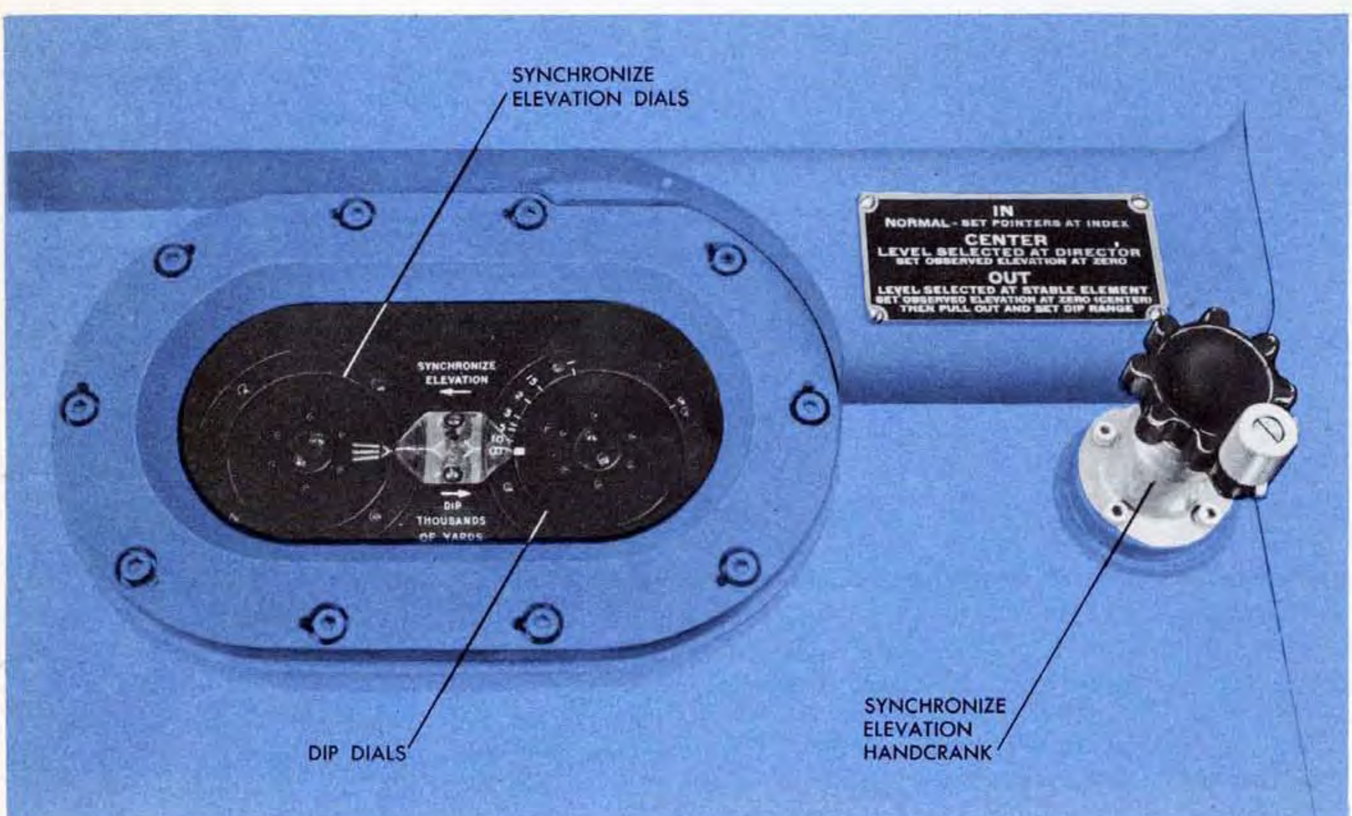


The rear top of the Computer Mark 1 is divided into three control groups:

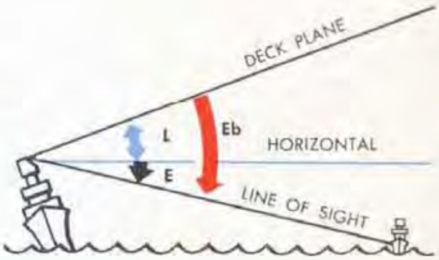
The Synchronize Elevation and Dip Group
The Spot Group
The Prediction Values Group

The synchronize elevation and dip dial group

This group consists of the Synchronize Elevation and Dip Dials and the Synchronize Elevation Handcrank.



THE SYNCHRONIZE ELEVATION DIALS consist of an inner dial and a ring dial. The index on the ring dial is a broken line. The index on the inner dial is an arrow. These markings are matched at the fixed index for Continuous Aim.

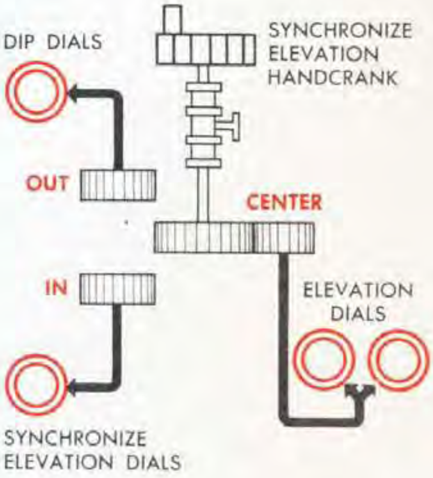


THE DIP DIALS consist of an inner dial with a wide index mark, and an outer ring with uneven graduations and numbers from 0.5 to infinity. The graduations on the outer dial represent thousands of yards of Range. The Dip Dials are used to obtain a substitute value for Target Elevation, *E*, when the Computer is operated without the Director. This substitute *E* is combined with Level Angle, *L*, to obtain a substitute value of Director Elevation, *Eb*, a value normally received from the Director.

THE SYNCHRONIZE ELEVATION HANDCRANK has three positions: IN, CENTER, and OUT, with a pin to lock it in each position.

In the IN position, the handcrank is connected to the Synchronize Elevation Dials. In preparing for Continuous Aim, this handcrank is turned in the IN position to match the Synchronize Elevation Dials at their fixed index.

In the CENTER position, the Synchronize Elevation Handcrank is connected to the Observed Elevation shaft line and the Elevation Dials on the front of the Computer. When the Computer is being set up for Selected Level Fire, with Level Angle selected at the Director, against a surface target, this handcrank is turned in the CENTER position to zero the Elevation Dials. It should be left in the CENTER position.



In the OUT position the Synchronize Elevation Handcrank is connected to the Dip Dials. When the Computer is being set up to fire against a surface target without the Director Elevation input, that is, in Indirect Fire from the Stable Element, this handcrank is turned in the OUT position to put in a Dip value. The Dip value is set by matching the index on the inner Dip Dial to the fixed index and then setting the value of Advance Range on the ring dial to the same fixed index. Dip is set in after the Elevation Dials have been zeroed with the handcrank in the CENTER position. The graduations on the Dip Dial actually represent thousands of yards of Present Range. Advance Range is used to set the dials, however, because it is easily read on the adjacent *R2* Counter and is sufficiently accurate for this purpose.

When the handcrank is in the IN position, ignore any motion of the Dip Dials. When the handcrank is in the CENTER position, ignore any motion of both the Dip Dials and the Synchronize Elevation Dials. When the handcrank is in the OUT position, ignore any motion of the Synchronize Elevation Dials.

The spot group

The Spot Group consists of two Range Spot Counters, the Elevation Spot Dial, the Deflection Spot Dial, the Range Spot Handcrank, the Elevation Spot Knob, and the Deflection Spot Knob.

THE TWO RANGE SPOT COUNTERS show Range Spot, *Rj*, in yards. The upper counter reads from zero to 1,800 OUT. The lower counter reads from zero to 12,000 IN. One counter is always masked while the other shows a value of Range Spot. Both counters are uncovered at the zero position.

THE ELEVATION SPOT DIAL shows Elevation Spot, *Vj*, in mils from DOWN 180 mils to UP 180 mils. The dial is graduated every 5 mils, numbered every 20 mils, and read against its fixed index.

THE DEFLECTION SPOT DIAL shows Deflection Spot, *Dj*, in mils from RIGHT 180 mils to LEFT 180 mils. The dial is graduated every 5 mils, numbered every 20 mils, and read against its fixed index.

THE RANGE SPOT HANDCRANK puts Range Spot, *Rj*, into the Range Spot Counters and the *Rj* shaft line.

THE ELEVATION SPOT KNOB puts Elevation Spot, *Vj*, into the Elevation Spot Dial and the *Vj* shaft line.

THE DEFLECTION SPOT KNOB puts Deflection Spot, *Dj*, into the Deflection Spot Dial and the *Dj* shaft line.

The two knobs and the handcrank each have two positions: IN and OUT, with pins to hold them in either position. To introduce a spot manually, the knobs and handcrank must be in their IN positions. For automatic reception of spots from the Director, the knobs and handcrank must be OUT.

CAUTION:
The *Rj*, *Vj*, and *Dj* Receivers can get out of synchronism with the incoming signals. To prevent this, see that the Spot Dials indicate the correct value of the spot before pulling the handcranks OUT.

Quick Reference Index

The prediction values group

The Prediction Values Group consists of the Sight Angle Counter and Handcrank, the Sight Deflection Counter and Handcrank, the Fuze Counter and Handcrank, and the Advance Range Counter.

THE SIGHT ANGLE COUNTER shows the computed value of Sight Angle, *Vs*, in minutes, with 2,000 minutes as the zero value.

THE SIGHT DEFLECTION COUNTER shows the computed value of Sight Deflection, *Ds*, in mils, with 500 mils as the zero value.

THE FUZE COUNTER shows the computed value of Fuze Setting Order, *F*, in seconds.

THE ADVANCE RANGE COUNTER shows the computed value of Advance Range, *R2*, in yards. There is no *R2* handcrank.

The handcranks in this group have two positions: IN and OUT, and each has a pin to hold it in either position.

THE SIGHT ANGLE HANDCRANK in its IN position is connected to the *Vs* shaft line and counter. When this knob is OUT, the *Vs* line is positioned by the Prediction Section of the Computer.

THE FUZE COUNTER

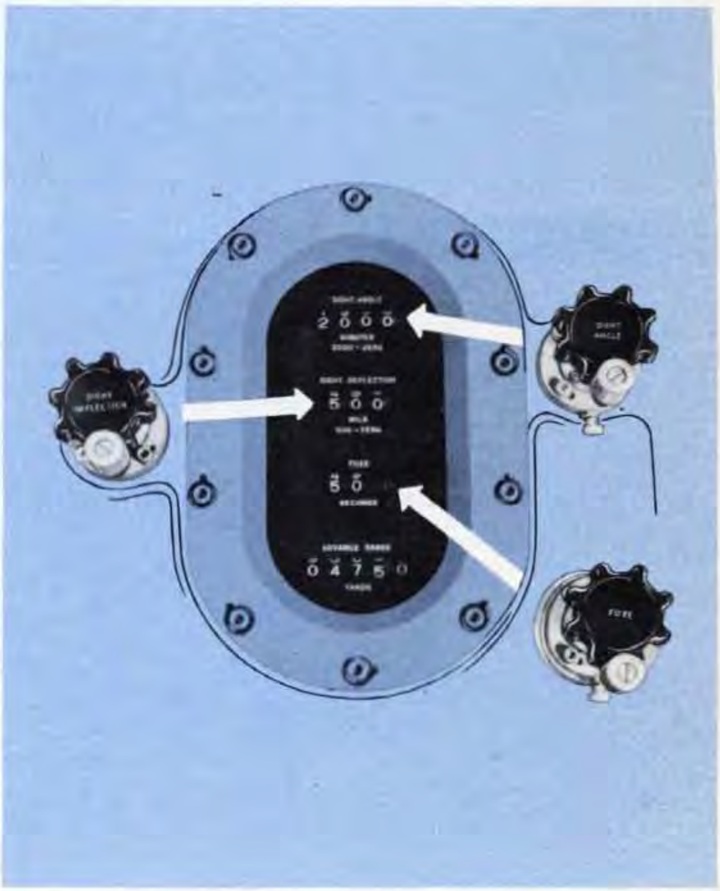
Read the white figures to obtain the number of whole seconds. Read the red figure and graduations to obtain the tenths of a second. Only the numbers 0 and 5 appear on the tenth-seconds drum. Hundredths of a second can be approximated by observing the relation of the tenth-seconds graduations to the fixed index. The counter reading above is 14.65 seconds.

THE SIGHT DEFLECTION HANDCRANK in its IN position is connected to the *Ds* shaft line and counter. When this knob is OUT, the *Ds* line is positioned by the Prediction Section of the Computer.

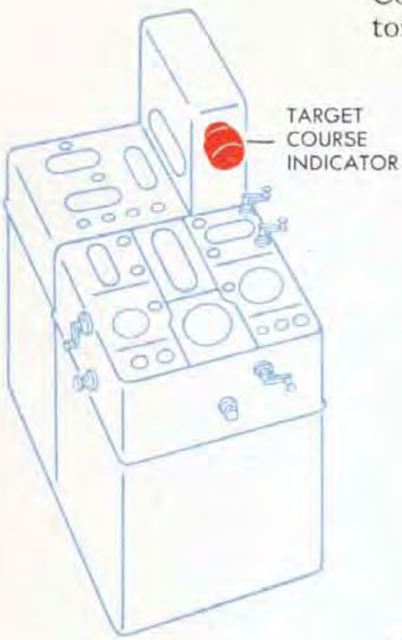
THE FUZE HANDCRANK in its IN position is connected to the *F* shaft line and counter. When this knob is OUT, the *F* line is positioned by the Prediction Section of the Computer.

If some of the power circuits should fail leaving the Sight Angle, Sight Deflection, and Fuze Transmitters energized, these transmitters can be set by hand through the handcranks to send values of *Vs*, *Ds* and *F* to the guns.

When no Star Shell Computer is supplied, the Fuze and Sight Angle Handcranks can be used in transmitting these values to the gun firing the star shells. The values to be used are obtained from a Star Shell Legend Plate.



THE TARGET COURSE INDICATOR



The Target Course Indicator is mounted on the Star Shell Computer. It has a Target Course Dial, an INCREASE Button, and a DECREASE Button.

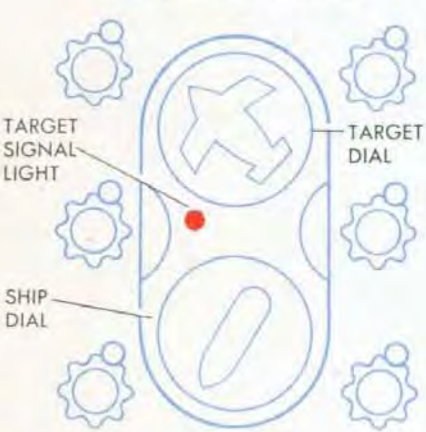
THE TARGET COURSE DIAL shows Target Course, *Ct*, which is the horizontal angle between *North* and the bow of the Target, measured clockwise from *North.*

An index plate around the dial is graduated in degrees from 0°, which represents *North,* to 360°, with graduations every 2 degrees and numbers every 10 degrees. Zeros are omitted so that the figures can be read more easily.

The dial has an airplane engraved on it. The bow of the Target is read against the index plate.

The dial is positioned by synchro transmission from the *Ct* Transmitter in the Computer.

TARGET AND SHIP GROUP



THE INCREASE AND DECREASE BUTTONS

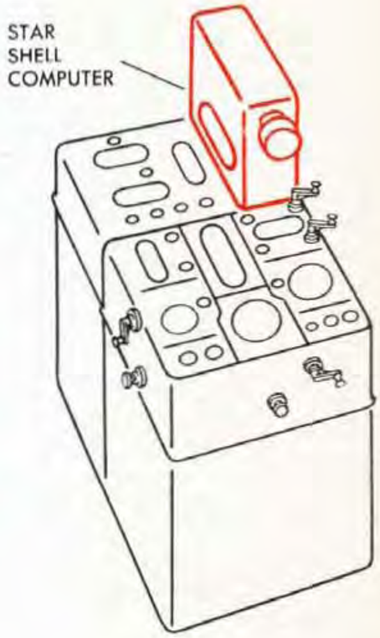
The *Ct* shaft line in the Computer may also be positioned manually by the push buttons on the Target Course Indicator. When the DECREASE Button is pressed, the value of *Ct* in the Computer decreases; when the INCREASE Button is pressed, the value of *Ct* in the Computer increases. The Target Course Indicator Dial shows the value of *Ct* in the Computer at all times. To make inputs at the Target Course Indicator, the Target Angle *and* Target Speed Handcranks must be positioned at AUTO.

THE TARGET SIGNAL LIGHT

On early modifications of the Computer Mark 1 there was a red signal light below the Target Dial. This signal light was ON only when a change in Target Angle was being put into the Computer through the Target Angle Repeater in the Director. This signal has been eliminated from later modifications of the Computer Mark 1.

THE STAR SHELL COMPUTER

The controls on the Star Shell Computer consist of the Star Shell Range Counter, the Star Shell Range Spot Dials and Knob, and the Star Shell Range Dials and Knob.

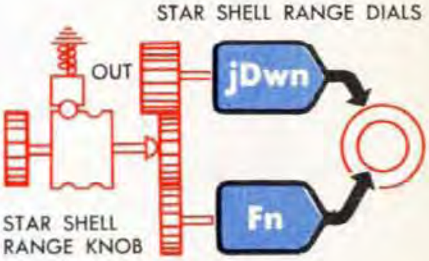


THE STAR SHELL RANGE COUNTER shows Star Shell Range, *R2n*. The reading of this counter, except as it may be modified by Star Shell Range Spot, *Rjn*, is 1000 yards higher than Advance Range, *R2*, which it receives from the Prediction Section of the Computer Mark 1. The 1000-yard offset, which is introduced at the time of adjustment, serves to cause star shells to burst beyond the Target.

THE STAR SHELL RANGE SPOT DIALS consist of an inner and an outer dial. The inner dial has an index on it and is positioned automatically by the Star Shell Spot Transmitter. The outer dial is graduated and numbered in hundreds of yards of Star Shell Range Spot, *Rjn*, from 1500 OUT to 1500 IN. The figures on the IN side are printed in red. This dial is positioned by the Star Shell Range Spot Knob.

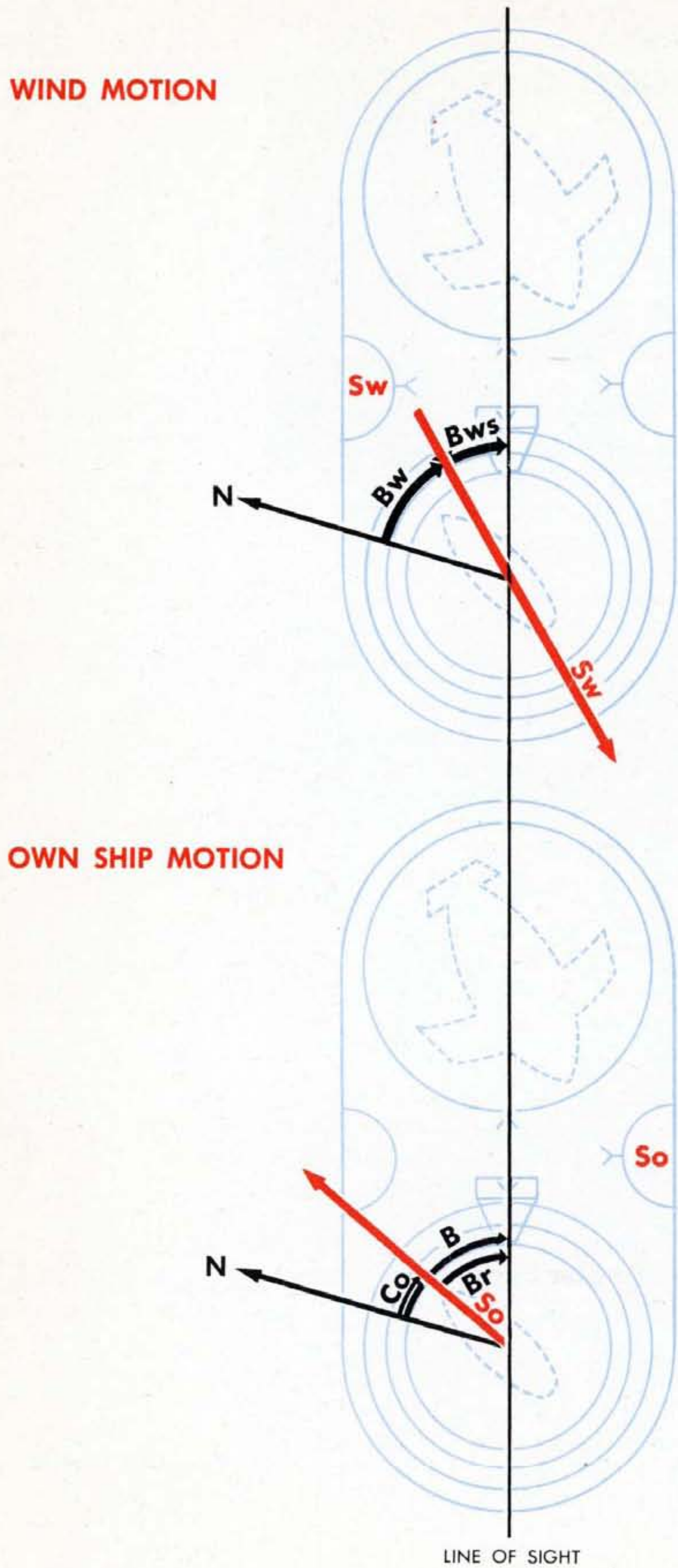
THE STAR SHELL RANGE SPOT KNOB sets Star Shell Range Spot, *Rjn*, into the outer Star Shell Range Spot Dial and the *Rjn* shaft line, when the outer *Rjn* Dial is matched to the inner *Rjn* Dial.

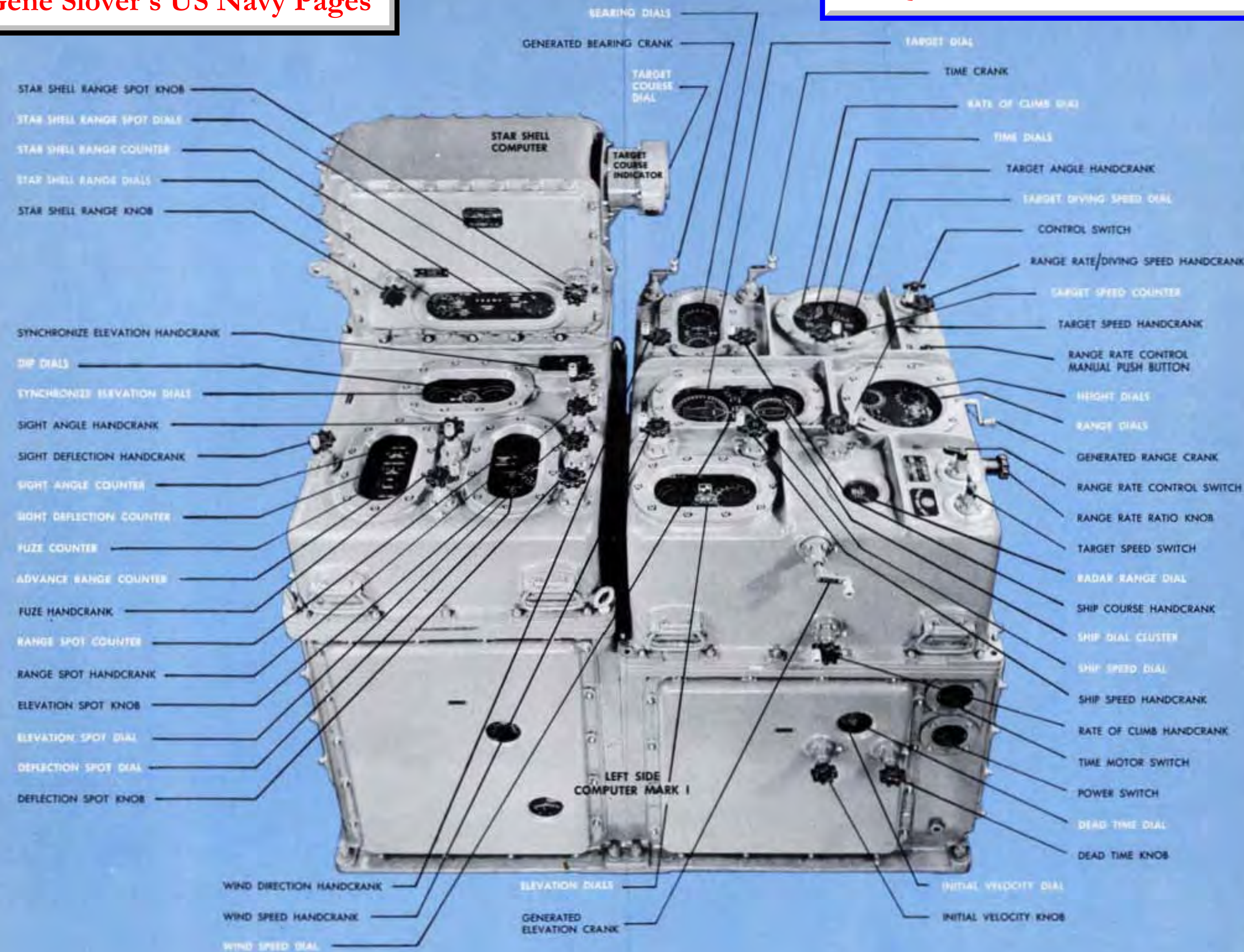
THE STAR SHELL RANGE DIALS consist of an inner and an outer dial. The inner Star Shell Range Dial is called the *Fn* Dial; the outer Star Shell Range Dial is called the *jDwn* Dial. Both dials have unevenly spaced graduations and are numbered in thousands of yards. These dials must be positioned by the Star Shell Range Knob so that the reading across their fixed index matches the reading on the Star Shell Range Counter.



THE STAR SHELL RANGE KNOB has two positions: IN and OUT, with a ball detent to hold it in either position. This knob is turned in its IN position to match the inner *Fn* Dial approximately to the Star Shell Range Counter reading. Then in its OUT position this knob is turned to move the outer *jDwn* Dial until the reading across the fixed index agrees exactly with the counter reading. In its IN position, the Star Shell Range Knob sets Star Shell Fuze Setting Order, *Fn*, into the Star Shell Computer. In its OUT position it sets in *jDwn*.

THE SHIP DIAL CLUSTER




BEARING DIALS
GENERATED BEARING CRANK
TARGET COURSE DIAL
TARGET DIAL
TIME CRANK
RATE OF CLIMB DIAL
TIME DIALS
TARGET ANGLE HANDCRANK
TARGET DIVING SPEED DIAL
CONTROL SWITCH
RANGE RATE/DIVING SPEED HANDCRANK
TARGET SPEED COUNTER
TARGET SPEED HANDCRANK
RANGE RATE CONTROL MANUAL PUSH BUTTON
HEIGHT DIALS
RANGE DIALS
GENERATED RANGE CRANK
RANGE RATE CONTROL SWITCH
RANGE RATE RATIO KNOB
TARGET SPEED SWITCH
RADAR RANGE DIAL
SHIP COURSE HANDCRANK
SHIP DIAL CLUSTER
SHIP SPEED DIAL
SHIP SPEED HANDCRANK
RATE OF CLIMB HANDCRANK
TIME MOTOR SWITCH
POWER SWITCH
DEAD TIME DIAL
DEAD TIME KNOB
INITIAL VELOCITY DIAL
INITIAL VELOCITY KNOB
STAR SHELL RANGE SPOT KNOB
STAR SHELL RANGE SPOT DIALS
STAR SHELL RANGE COUNTER
STAR SHELL RANGE DIALS
STAR SHELL RANGE KNOB
STAR SHELL COMPUTER
TARGET COURSE INDICATOR
SYNCHRONIZE ELEVATION HANDCRANK
DIP DIALS
SYNCHRONIZE ELEVATION DIALS
SIGHT ANGLE HANDCRANK
SIGHT DEFLECTION HANDCRANK
SIGHT ANGLE COUNTER
SIGHT DEFLECTION COUNTER
FUZE COUNTER
ADVANCE RANGE COUNTER
FUZE HANDCRANK
RANGE SPOT COUNTER
RANGE SPOT HANDCRANK
ELEVATION SPOT KNOB
ELEVATION SPOT DIAL
DEFLECTION SPOT DIAL
DEFLECTION SPOT KNOB
LEFT SIDE COMPUTER MARK I
WIND DIRECTION HANDCRANK
WIND SPEED HANDCRANK
WIND SPEED DIAL
ELEVATION DIALS
GENERATED ELEVATION CRANK

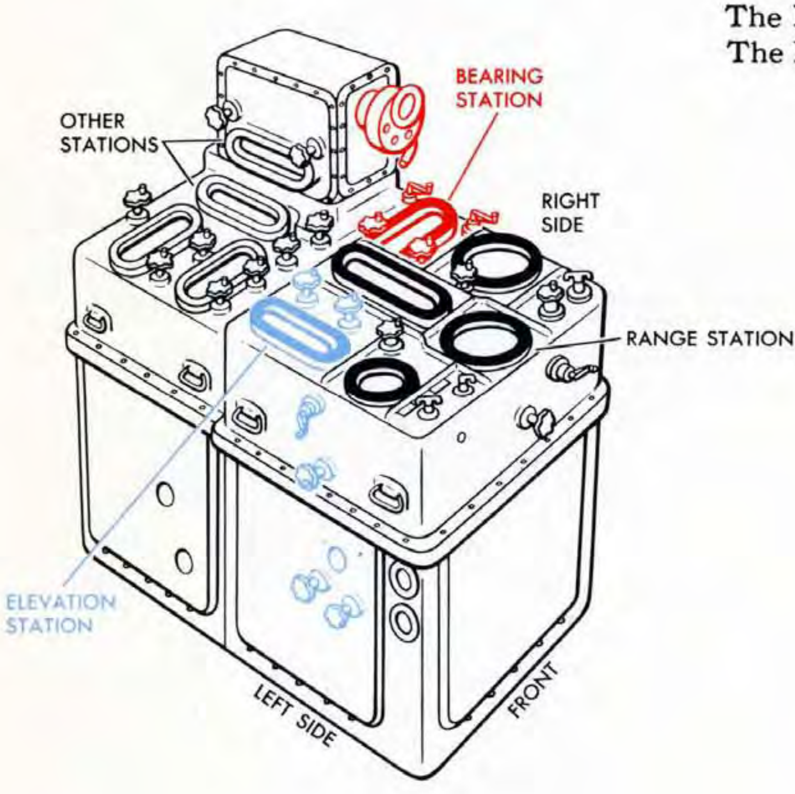
OPERATING INSTRUCTIONS

Operating Stations

The number of men operating the Computer Mark 1 and the duties assigned to each man are determined by ship's doctrine.

For convenience in describing operating procedures in this chapter, the principal controls of the Computer are divided among three operating stations:

The Range Station at the front
The Elevation Station at the left side
The Bearing Station at the right side



Each of these stations may be manned by one or more operators. If necessary one operator can man more than one station. For convenience it is assumed here that there is one operator at each of the three stations.

In the operating instructions that follow, the duties of the men at the three main stations are always given first. Additional duties are grouped under "Other Stations."

The Conditions of the Computer

The Computer controls must always be set in such a way that the Computer can be put into operation quickly. When no action is expected, the controls should be positioned to avoid needless wear of the Computer parts. The suggested settings for the Computer when it is not in use are grouped under the title, *Secured Condition of the Computer.*

When a search for a target begins, several changes may be made to these settings to prepare for action. When the type of target is not known, the Computer is put into the *Standby for Search* condition. When the type of target is known, the Computer may be put into *Standby for an Air Target* or *Standby for a Surface Target.*

When tracking a target, the Computer may be operated in several different ways. There are four basic types of operation: Automatic, Semi-automatic, Manual, and Local (without Director). In actual practice, features of two or more of these types are often combined.

The instructions which follow describe the steps required to change the Computer:

1 From *Secured* to *Standby for Search*

2 From *Standby for Search* to *Standby for an Air Target*

3 From *Standby for an Air Target* to each of the basic types of operation used for air targets. The basic types of operation for an air target are: Auto, Semi-auto, and Manual.

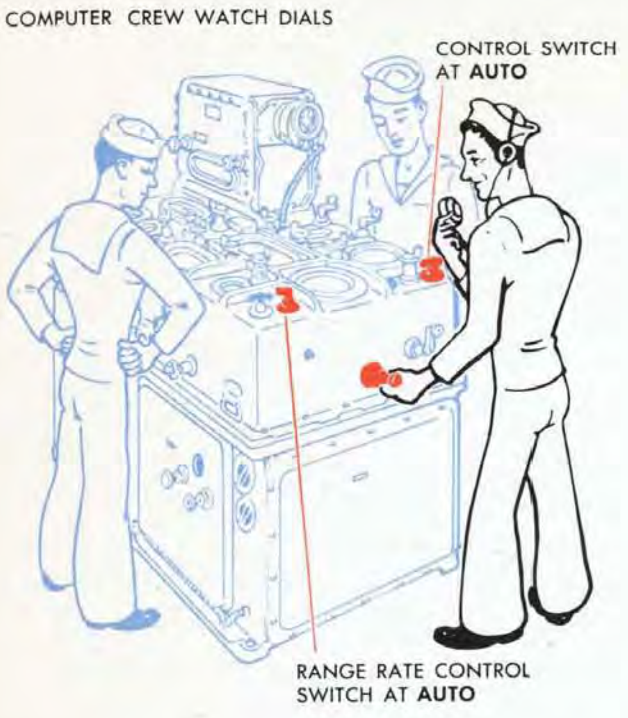
4 From *Standby for Search* to *Standby for a Surface Target.*

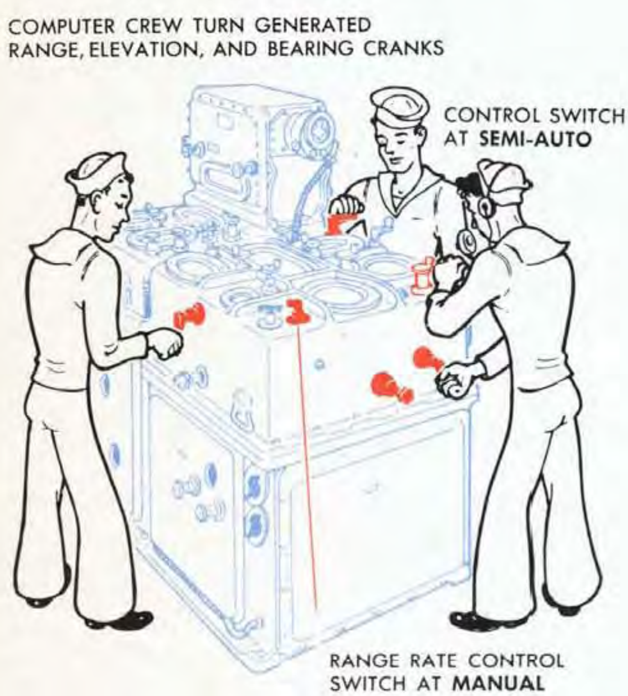
5 From *Standby for a Surface Target* to each of the basic types of operation used for surface targets. The basic types of operation for a surface target are: Manual and Local.

Operators who are familiar with these procedures will be able to change from any condition or type of operation to any other condition or type of operation

The Standby Conditions discussed on pages 116, 118, and 132, are a compromise between *speed* in shifting to full operation, and *prevention of wear.* There are other Standby setups which put greater emphasis on *speed* and less emphasis on *prevention of wear.* Samples of these faster setups are included on pages 146-147.

The FOUR TYPES of OPERATION





NOTE:
Range can be rate-controlled semi-automatically while Elevation and Bearing are being rate-controlled automatically. Likewise, Range can be rate-controlled automatically while Elevation and Bearing are being rate-controlled semi-automatically.

In Automatic and Semi-automatic Operation, the Rate Control Group computes corrected values of *Sh, dH,* and *A*.

AUTOMATIC OPERATION

In Automatic Operation the Rate Control Group computes the corrected values of *Sh, dH,* and *A,* on signal from the Director. When the Pointer and Trainer press their signal keys as they turn their handwheels, Elevation and Bearing Rate Control Corrections automatically feed into the Rate Control Group. When the Range Operator presses his Range Signal Button as he turns his Range Knob, Range Rate Control Corrections enter the Rate Control Group. The amount of Range Rate Control Correction is controlled manually by the Range Rate Ratio Knob at the Computer. A solution is reached when the Elevation and Bearing Solution Indicators cease turning.

Switch Positions:

Control Switch at AUTO
Range Rate Control Switch at AUTO

SEMI-AUTOMATIC OPERATION

In Semi-automatic Operation the Rate Control Group computes the corrected values of *Sh, dH,* and *A,* using Rate Control Corrections put in by hand by the Computer Crew. The Computer Crew makes rate corrections by turning the Generated Range, Generated Elevation, and Generated Bearing Cranks. These cranks are turned in their IN positions when the signals from the Director show that Observed Range, Observed Elevation, and Observed Bearing are correct. A solution is reached when sufficient corrections have been put in to keep the Generated Range, Generated Elevation, and Generated Bearing Dials rotating in the same directions and at the same rates as the Observed Range, Observed Elevation, and Observed Bearing Dials.

Switch Positions:

Control Switch at SEMI-AUTO
Range Rate Control Switch at MANUAL

In Manual and Local Operation, the Rate Control Group is not used. Instead, the operators correct *Sh*, *dH*, and *A* directly by means of the *Sh*, *dH*, and *A* Handcranks.

MANUAL OPERATION

In Manual Operation the Computer Crew makes rate corrections through the *Sh*, *dH*, and *A* Handcranks. A solution is reached when sufficient corrections have been made to the Target Motion values to keep the Generated Range, Generated Elevation, and Generated Bearing Dials rotating in the same directions and at the same rates as the Observed Range, Observed Elevation, and Observed Bearing Dials.

Switch Positions:

Control Switch at SEMI-AUTO
Range Rate Control Switch at MANUAL

LOCAL OPERATION

Local Operation is a type of operation used when Target Position is not being completely determined by the Gun Director Mark 37. Observed Range, *R*, Relative Target Bearing, *Br*, Target Angle, *A*, and Target Speed, *Sh*, are observed from some aloft station and continually phoned to the plotting room. The Computer Crew puts the values of these quantities into the Computer by hand at the Generated Range, Generated Bearing, Target Angle, and Target Speed Handcranks. The crew then corrects the values of *Sh* and *A* through the Target Speed and Target Angle Handcranks. The solution of the problem is reached when the readings on the Range and Bearing Dials stay in agreement with the phoned values.

Switch Positions:

Control Switch at LOCAL
Range Rate Control Switch at MANUAL

SECURED CONDITION

Securing the COMPUTER MARK 1

At the Range Station:
1 Turn the Time Motor Switch OFF.

At the Other Stations:
1 Set Level at a selected value of 2000 minutes at the Stable Element.
2 Disconnect Cross-level and set it at a selected value of 2000 minutes. On some ships this is done at the Selector Drive; on other ships it is done at the Stable Element.

Setting the handcranks and dials in Secured Condition

All handcranks, switches, and dials should be set at definite positions whenever the Computer is secured. Knowing the settings makes it possible to go into operation fast. If the same settings are used consistently, any changes from them can be recognized as evidence of tampering.

The settings used may vary according to ship's doctrine. The following settings are suggested:

At the Range Station:
1 Turn the Control Switch to LOCAL.
2 Put the Range Rate Diving Speed Handcrank to AUTO.
3 Turn the Range Rate Control Switch to MANUAL.
4 Turn the Target Speed Switch to NORMAL.
5 With the Target Speed Handcrank at HAND, set *Sh* at zero. Leave the handcrank at HAND.
6 Set the Range Rate Ratio Knob at 1.
7 With the Generated Range Crank OUT, set the Range Dials at 30,000 yards. Leave the crank OUT.

At the Elevation Station:
1 With the Rate of Climb Handcrank IN, set *dH* at zero. Leave the handcrank IN.
2 Set the Generated Elevation Crank at the OUT position.
3 With the Ship Speed Handcrank IN, set *So* at zero. Leave the handcrank IN.
4 With the Wind Speed Handcrank, set *Sw* at zero.
5 With the Synchronize Elevation Handcrank at CENTER, set *E* at zero. Leave the handcrank at CENTER.
6 Pull the Initial Velocity Knob OUT and set *I.V.* at 2600 f.s.
7 Pull the Dead Time Knob OUT and set *Tg* at the established value.

The Initial Velocity and Dead Time Knobs return to their IN positions when released.

At the Bearing Station:

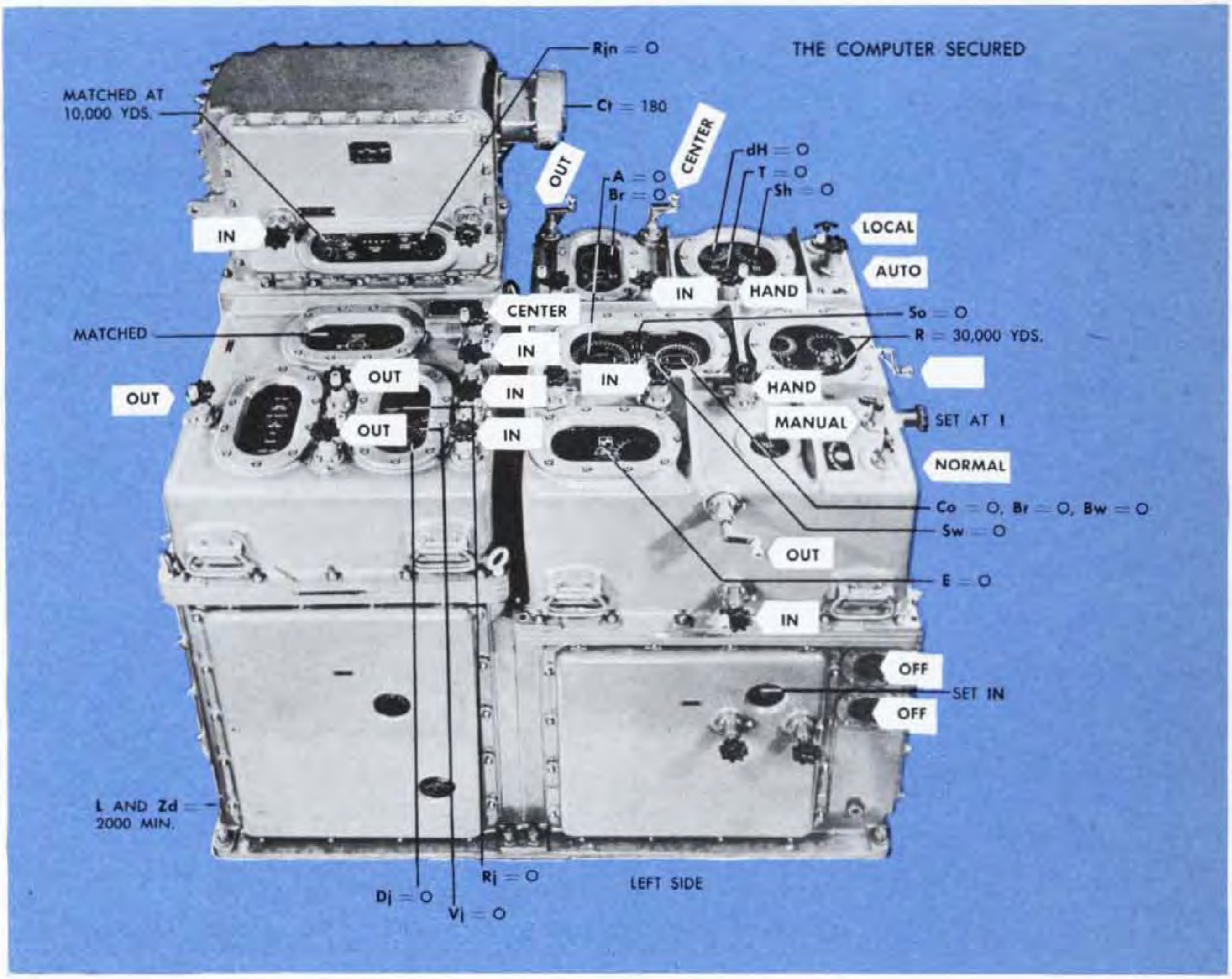
1 With the Ship Course Handcrank IN, set *Co* at zero. Leave the handcrank IN.
2 With the Wind Direction Handcrank, set *Bw* at zero.
3 With the Generated Bearing Crank OUT, set *Br* at zero. Leave the crank OUT.
4 With the Target Angle Handcrank at HAND, set *A* a zero. Leave the handcrank at HAND.
5 Push the Time Crank IN and zero the Time Dials. When the crank is released it returns to the CENTER position.

At the Other Stations:

1 With the Range Spot Handcrank and the Elevation and Deflection Spot Knobs IN, set *Rj*, *Vj*, and *Dj* at zero.
2 Leave the Sight Angle, Sight Deflection and Fuze Handcranks OUT.
3 With the Star Shell Range Spot Knob, set *Rjn* at zero.
4 With the Star Shell Range Knob IN, set the inner dial at 10,000 yards. Pull the knob OUT and set the outer dial at 10,000 yards. Push the knob IN.

After all settings are made:

1 Turn the Power Switch OFF.
2 Turn the Computer Power Supply Switch OFF at the Switchboard.



STANDBY CONDITION

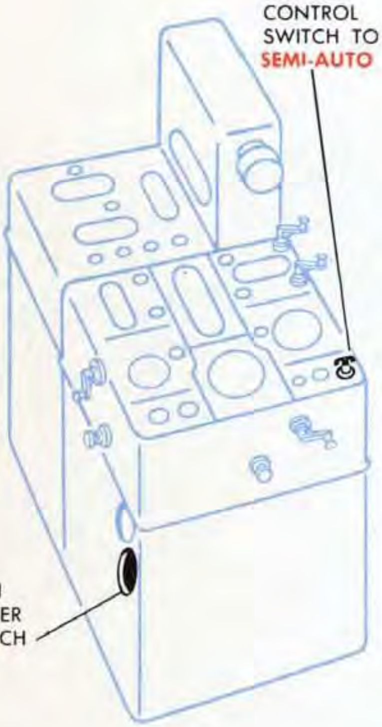
There are several Standby Conditions for the Gun Director Mark 37 System. These Standby Conditions and their names are determined by ship's doctrine. The Computer will be in one of the three following Standby Conditions, depending upon the System Standby Condition ordered.

Initial standby

Initial Standby is used only when there is little possibility of action.
The Computer is in *Secured* Condition.
Only the Stable Element gyro is energized.
The Computer circuits and all other circuits are de-energized.
This condition keeps wear of the Computer at a minimum.

Standby for search

The Stable Element gyro and follow-ups are energized.
Level and Cross-level are set at selected values.
The Computer power circuit is energized.
The synchro circuits are not energized.
The *Standby for Search* Condition keeps the system in instant readiness to begin searching without causing needless wear of the Computer parts.



Standby during search

All circuits in the Stable Element and Computer are energized except the Director Elevation Transmission circuit to the *Eb* Receiver.
Level and Cross-level are set at selected values.

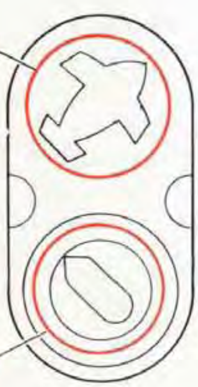
Changing from secured to standby for search and standby during search

At the Range Station:

1. Turn the Power Switch ON.
2. Turn the Control Switch to SEMI-AUTO.
3. Pull the Ship Course Handcrank OUT.
4. Set in ordered value of *I.V.*

The other Computer settings remain the same as for *Secured* Condition.

The Computer Dials During Search

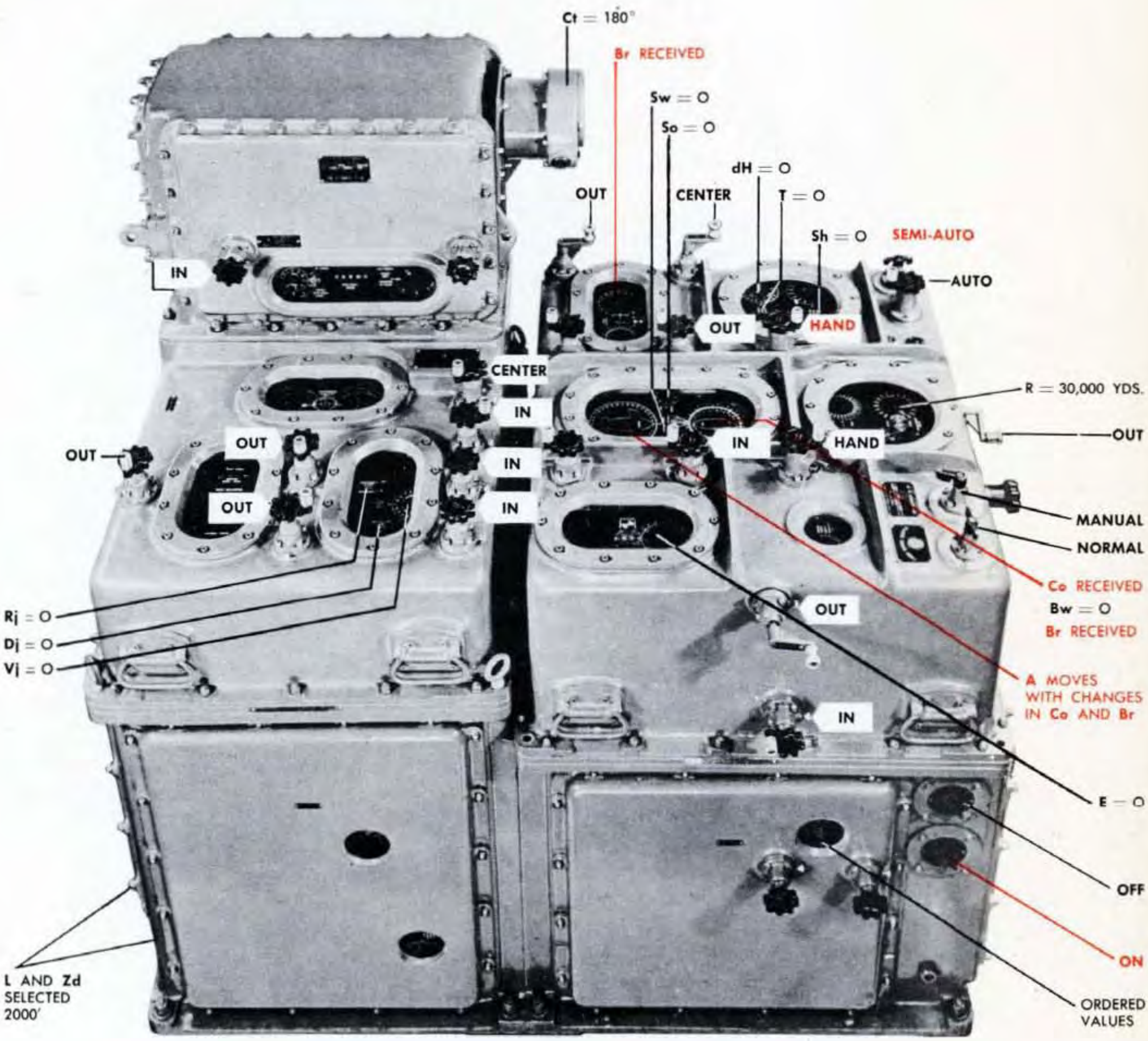


With the Power Switch ON, and the Switchboard positioned so that the Computer is in *Standby during Search*, the following dials move:

1. The Compass Ring Dial shows Ship Course, *Co*. This value is received from the Gyro Compass because the Ship Course Handcrank is OUT.
2. The Ship Dial turns and Relative Target Bearing, *Br*, changes as the Director trains in search of the target.
3. The Target Dial turns as Own Ship changes course and as Relative Target Bearing changes.

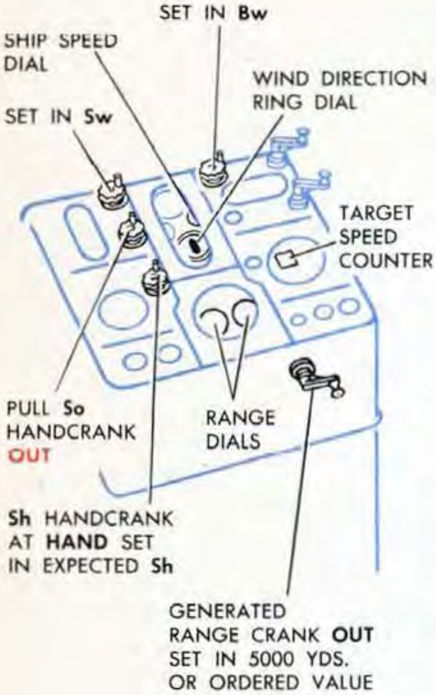
As soon as the type of target is known, additional settings may be made.

THE COMPUTER IN STANDBY DURING SEARCH



CHANGES FROM SECURED SHOWN IN RED

STANDBY FOR AN AIR TARGET



Changing from standby during search to standby for air target

At the Range Station:

1 With the Generated Range Crank OUT, match the "Y" indexes on the ring dials to the pointers on the inner dials. Set the ring dials at 5000 yards until an accurate range can be determined. Leave the crank OUT.

2 With the Target Speed Handcrank at HAND, set the estimated Target Speed into the Target Speed Counter. Leave the Handcrank at HAND.

At the Elevation Station:

1 With the Ship Speed Handcrank IN, set in the approximate *So;* then pull the handcrank OUT.

2 With the Wind Speed Handcrank, set in Wind Speed, *Sw*.

At the Bearing Station:

1 With the Wind Direction Handcrank, set in Wind Direction, *Bw*.

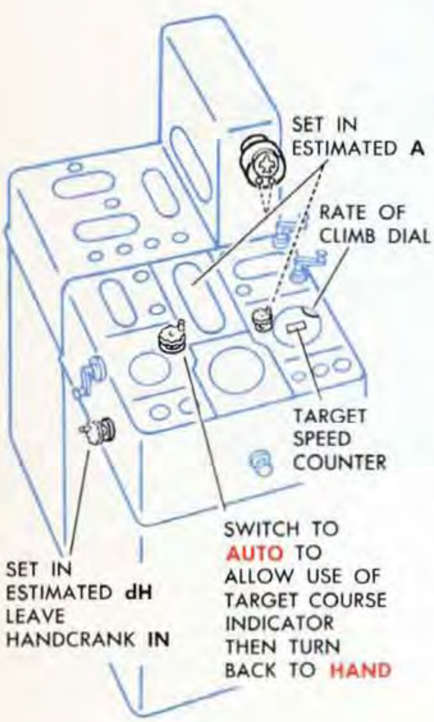
At the Other Stations:

1 Put the Stable Element at Continuous Aim.

2 Connect, synchronize, and lock the Selector Drive.

3 Make sure that all the switches connecting the Director, the Computer, the Stable Element, and the guns are ON at the Fire Control Switchboard.

4 Pull Spot Knobs OUT, noting that correct values of *Rj*, *Vj*, and *Dj* are indicated.



Setting in estimates of A, Sh, and dH

At the Range Station:

1 With the Target Angle Handcrank at HAND, set the estimated value of Target Angle, *A*, into the Target Dial. Leave the handcrank at HAND.

OR

Switch the Target Speed and Target Angle Handcrank to AUTO. At the Target Course Indicator press the INCREASE or DECREASE push-button until the estimated *A* is read on the Target Angle Dial. Return the handcranks to HAND position.

2 With the Target Speed Handcrank at HAND, set the estimated *Sh* into the Target Speed Counter.

3 With the Rate of Climb Handcrank in the IN position, set the estimated *dH* into the Rate of Climb Dial. Leave the handcrank IN.

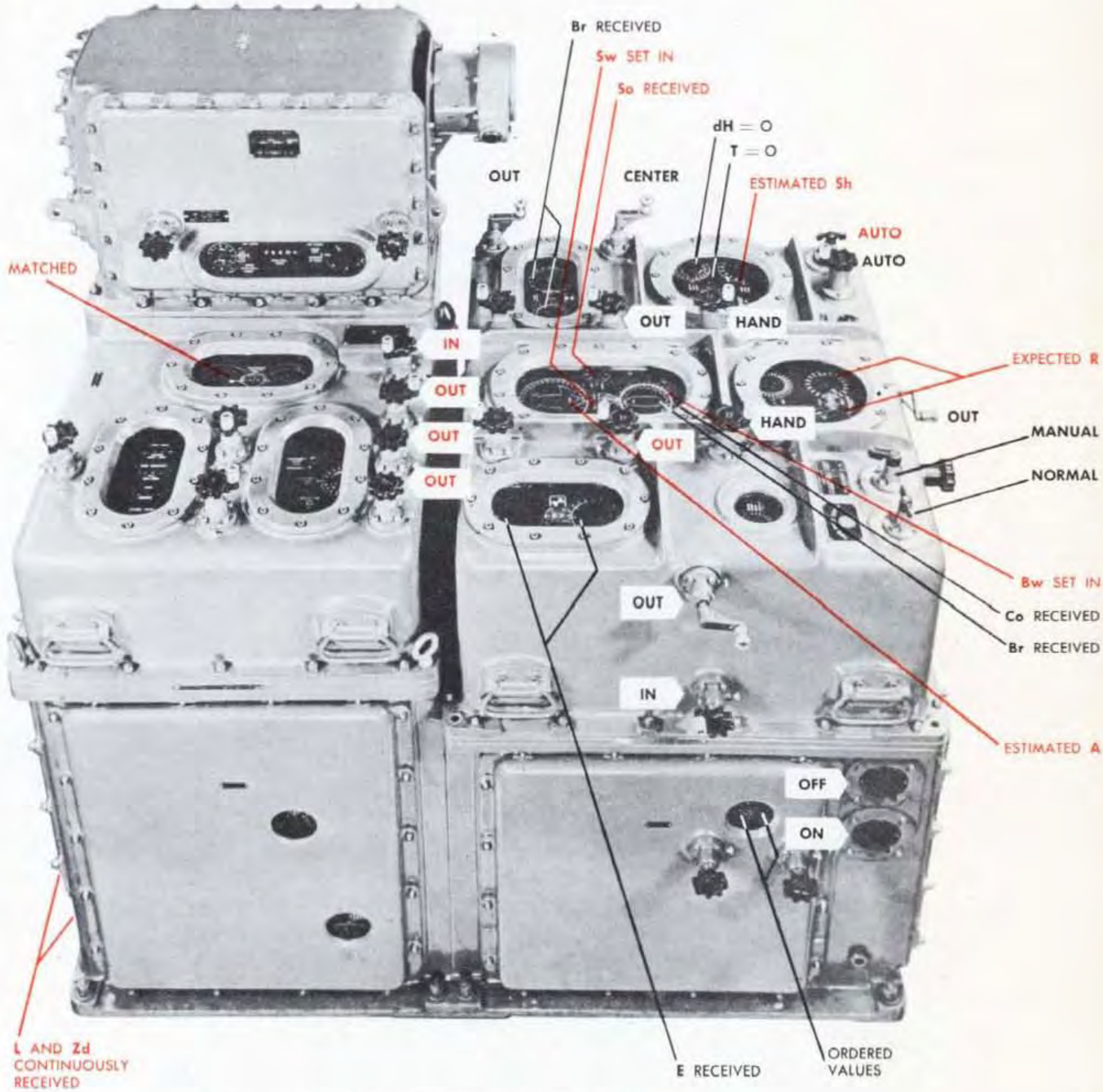
4 Turn the Control Switch to AUTO.

At the Elevation Station:

1 When the Director Sights are on the Target, push the Synchronize Elevation Handcrank IN and match the Synchronize Elevation Dials at the index.

2 See that Dead Time, *Tg*, and Initial Velocity, *I.V.*, are set at their ordered values.

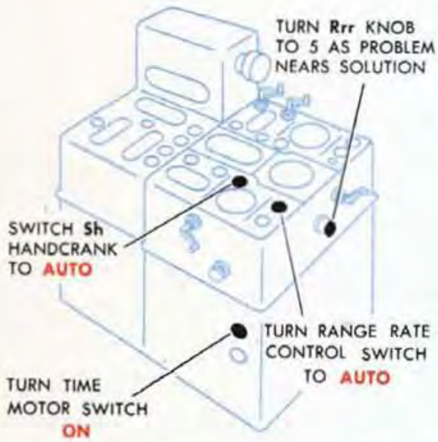
THE COMPUTER IN STANDBY FOR AN AIR TARGET

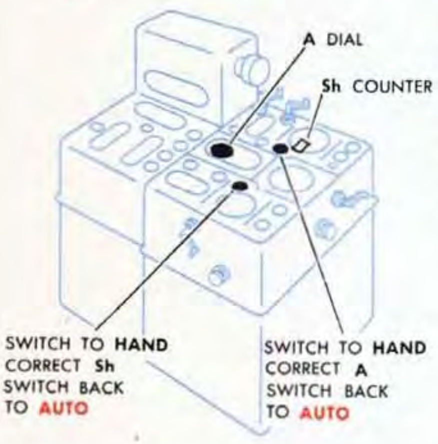


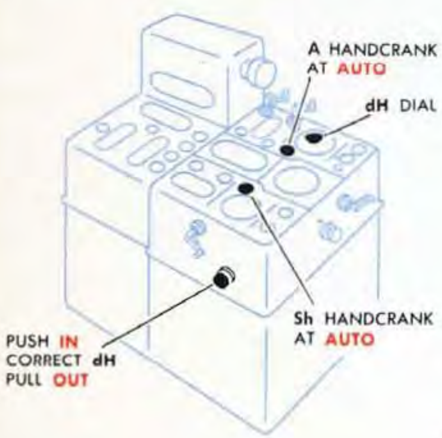
CHANGES FROM STANDBY SHOWN IN RED

When the Director Sights are positioned on the Target, the Pointer, Trainer and Range Finder Operator in the Director indicate they are ready to start tracking by closing their signal keys. When the signal keys are closed, the Range Finder Signal on the Computer turns to white, and the Pointer's and Trainer's Signals turn to red.

NOTE:
Range Rate should be controlled in AUTO only when the Range input from the Director is smooth and accurate. Even when receiving Radar Range it is advisable to rate-control manually until the ranges smooth out. With optical ranging, Automatic Rate Control should not be used unless at least 40 accurate ranges per minute are received.







AUTOMATIC OPERATION

Changing from standby for an air target to automatic operation

At the Range Station:

1. Turn the Range Rate Control Switch to AUTO.
2. Turn the Time Motor Switch ON.
3. Shift the Target Speed and Target Angle Handcranks to AUTO.

At the Elevation Station:

1. Pull the Rate of Climb Handcrank OUT.

Tracking in automatic operation

At the Range Station:

1. Turn the Range Rate Ratio Knob toward 5 as the problem nears solution. When the rate corrections become small, the Generated Range Dials will oscillate if the Range Rate Ratio Knob is positioned at too low a figure.

Making target corrections during automatic operation

If a large correction to a Target value is needed, it is always advisable to assist the Rate Control Mechanism by quickly setting in the new value by hand.

At the Range Station:

1. When ordered, correct Target Speed with the lever on the handcrank at HAND. Switch the lever back to AUTO as soon as the correction has been made.

   OR

   Leave the Target Speed and Target Angle Handcranks at AUTO. Correct Target Speed by holding the Target Speed Switch at either INCREASE or DIVE ATTACK until the new value is read on the Target Speed Counter.
2. When ordered, correct Target Angle with the lever on the handcrank at HAND. Switch the lever back to AUTO as soon as the correction has been made.

   OR

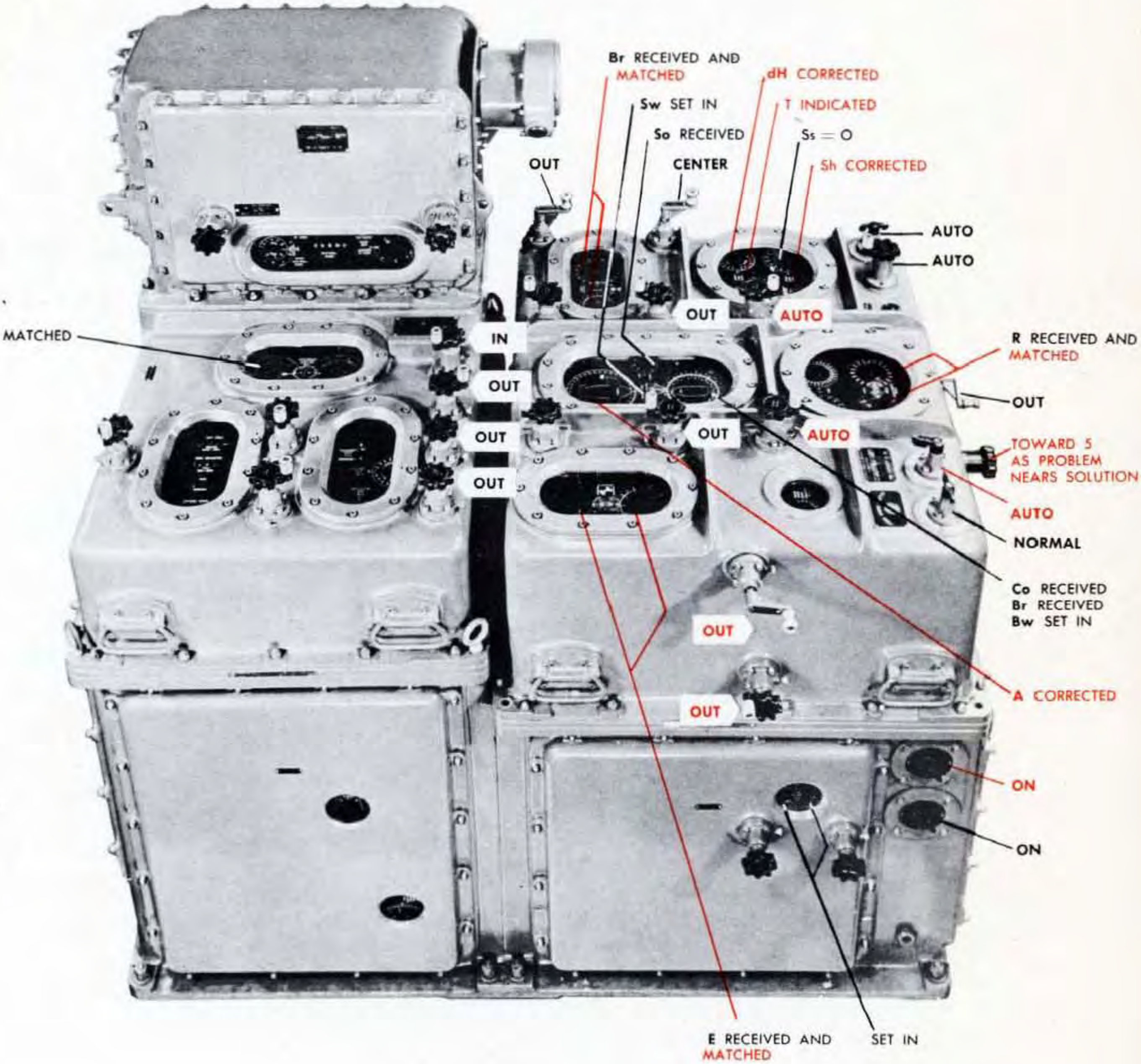
   Leave the Target Angle and Target Speed Handcranks at AUTO. Correct Target Angle by pressing one of the push buttons on the Target Course Indicator until the new value is read on the *A* Dial.

At the Elevation Station:

1. When ordered, make corrections to Rate of Climb with the *dH* Handcrank IN. Pull the handcrank OUT as soon as the correction has been made.

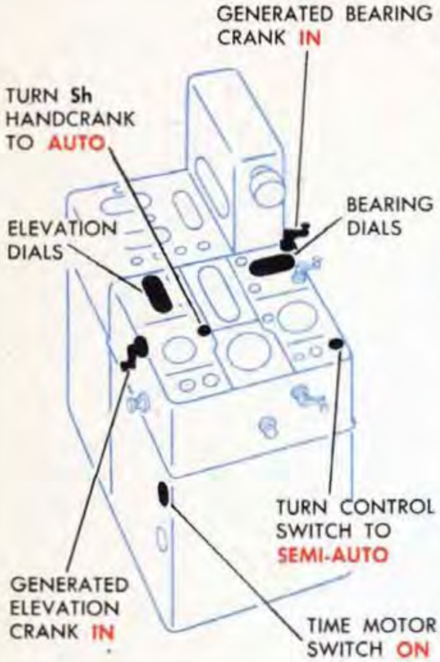
The Computer Crew now watches the Ship, Target, and Generated Dials, and stands ready either to make hand corrections, to change the method of operation, or to cease tracking.

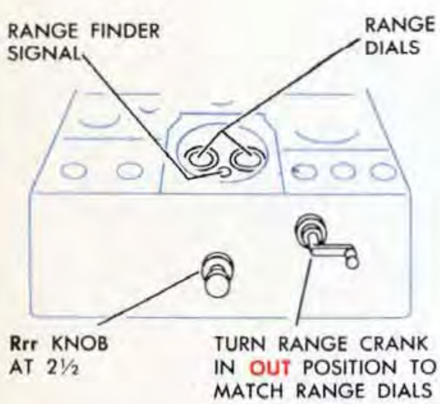
THE COMPUTER IN AUTOMATIC OPERATION

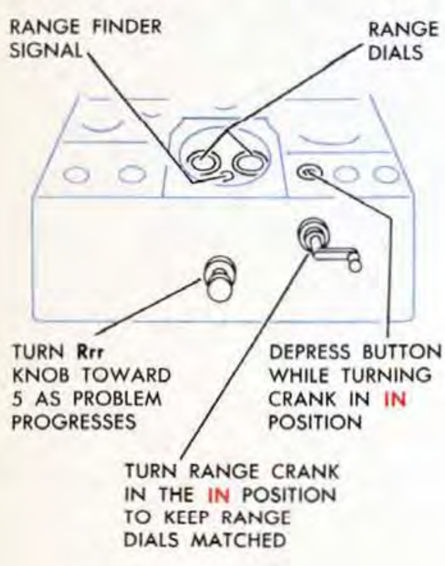


CHANGES FROM STANDBY FOR AN AIR TARGET SHOWN IN RED.

SEMI-AUTOMATIC OPERATION







Changing from standby for an air target to semi-automatic operation

At the Range Station:

1. Turn the Control Switch to SEMI-AUTO.
2. Turn the Time Motor Switch ON.
3. Shift the lever on the Target Speed Handcrank to AUTO.

At the Elevation Station:

1. Put the Generated Elevation Crank IN.

At the Bearing Station:

1. Put the Generated Bearing Crank IN.

Rate control in semi-automatic operation

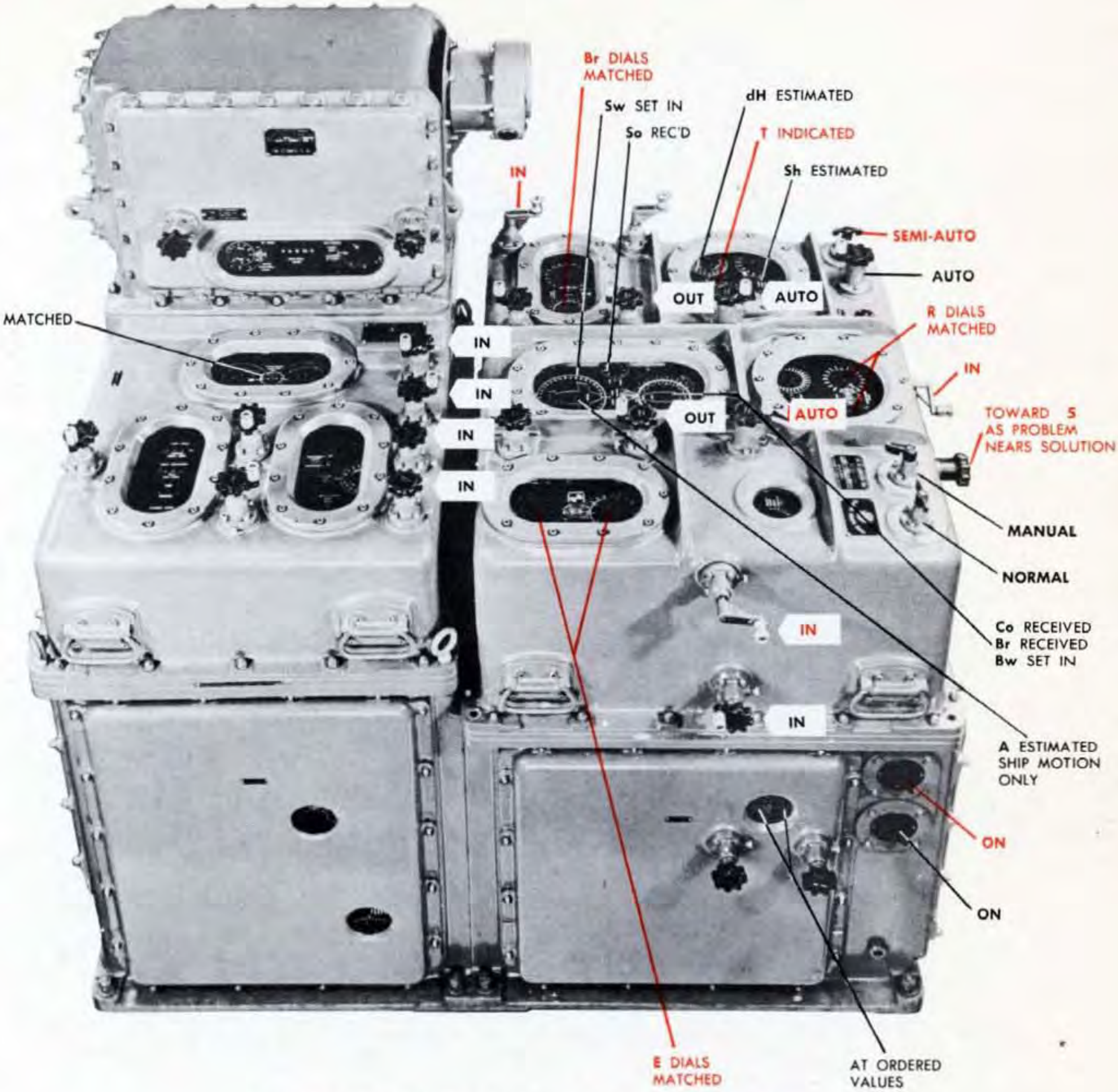
In Semi-automatic Operation, rate-controlling should be done at all stations at the same time.

At the Range Station:

1. Match the Range Dials.
   To do this, put the Generated Range Crank in its IN position. When the Range Finder Signal shows white, pull the crank OUT against spring pressure and turn it until the indexes on the Generated Range Dials match the indexes on the Observed Range Dials. The dials may also be matched with the crank in its IN position. When the crank is turned in its IN position, the amount of dial change for a given crank rotation depends on the position of the Range Rate Ratio Knob. With this knob at 1, a large crank movement makes a small dial change. With the knob at 5, the same crank movement causes a much greater dial change. A good Range Rate Ratio Knob setting for beginners is 2½. Experienced operators will sense the proper setting.
2. Keep the Generated Range Dials rotating at such a rate and in such a direction that they match the Observed Range Dials whenever the Range Finder Signal is white.
   To do this, depress the Range Rate Control Manual Push-button and turn the Generated Range Crank in its IN position while the Range Finder Signal is white. Turn the crank until the dials match. Turning the crank in its IN position with the push-button depressed puts Range *Rate* Corrections into the Rate Control Mechanism.
   The ratio of the *Rate* Corrections to the *Linear* Corrections is determined by the position of the Range Rate Ratio Knob.
   If there is a great difference in rate of rotation between the Generated and Observed Range Dials, it is advisable to over-correct. To over-correct, depress the Range Rate Control Manual Push-button and turn the Generated Range Crank in its IN position until the index on the fine outer dial passes the index on the fine inner dial. Then release the push-button and turn the crank back to match the indexes on the dials.

THE COMPUTER IN SEMI-AUTOMATIC OPERATION

SETTINGS AT THE MOMENT THAT THE TIME MOTOR IS TURNED ON

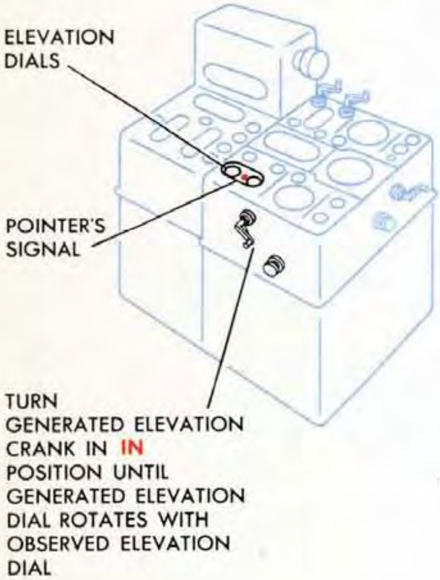


CHANGES FROM STANDBY FOR AN AIR TARGET SHOWN IN RED

The Range Rate Ratio Knob should be at the 1 position at the beginning of a problem or whenever large rate corrections are required. This knob should be turned to its next higher-numbered position whenever there is any oscillation of the Target Speed, *Sh*, Counter. As the problem progresses and the rate of rotation of the Generated Dials nears the rate of rotation of the Observed Dials, turn the Range Rate Ratio Knob toward its 5 position.

When the Generated Dials match the Observed Dials each time the Range Signal turns white, Generated Range and Range Rate are correct.

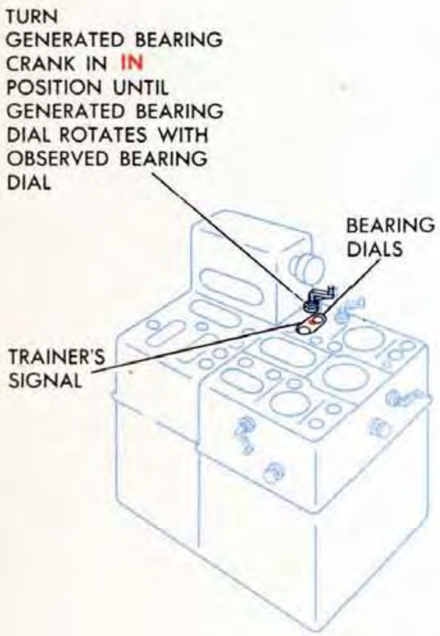
Rate-controlling at the elevation and bearing stations



At the Elevation Station:

1 With the Generated Elevation Crank in the IN position, turn it until the Generated Elevation Dial rotates with the fine Observed Elevation Dial. Over-correcting Elevation will cause false values of Rate of Climb and Range Rate to be computed.

When the Generated Elevation Dial and the fine Observed Elevation Dial rotate together, the Elevation Rate is correct.



At the Bearing Station:

1 With the Generated Bearing Crank in the IN position turn it until the Generated Bearing Dial rotates with the fine Observed Bearing Dial.

When the Generated Bearing Dial and the fine Observed Bearing Dial rotate together, the Bearing Rate is correct.

NOTE:
The speed with which rate corrections can be made will be determined by the skill of the operators. With experience the operators can judge the amount of crank rotation needed for any correction and make the whole correction quickly.

TARGET ANGLE

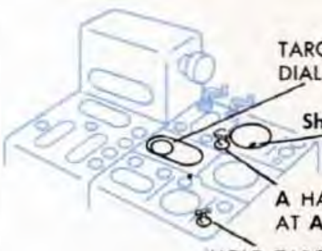
In Automatic or Semi-automatic Operation, a large fast change in Target Angle may cause the Rate Control Mechanism to compute a solution based on an incorrect Target Angle. Whenever this occurs, the reading on the Target Speed Counter drops rapidly to below 80 knots and all the dials showing generated values slow down. In Semi-automatic Operation, the Generated Bearing Dials rotate in the opposite direction to the Observed Bearing Dials. Finally the Target Angle Dial starts to vibrate.

To avoid a false solution, watch the Target Speed Counter. As soon as the reading on this counter drops below 80 knots:

1 Hold the Target Speed Switch at INCREASE until the former value of Target Speed shows up on the counter. Let the switch spring back to NORMAL. The Computer will then compute the correct Target Angle.

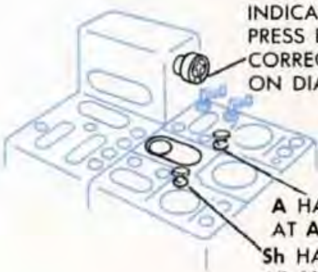
OR

2 When the report of a large change of Target Angle is received, switch the Target Angle Handcrank to HAND and make the correction to Target Angle while holding the Target Speed Switch at INCREASE. Hold the switch at INCREASE until the former value of Target Speed shows up on the counter. Switch the Target Angle Handcrank back to AUTO.



OR

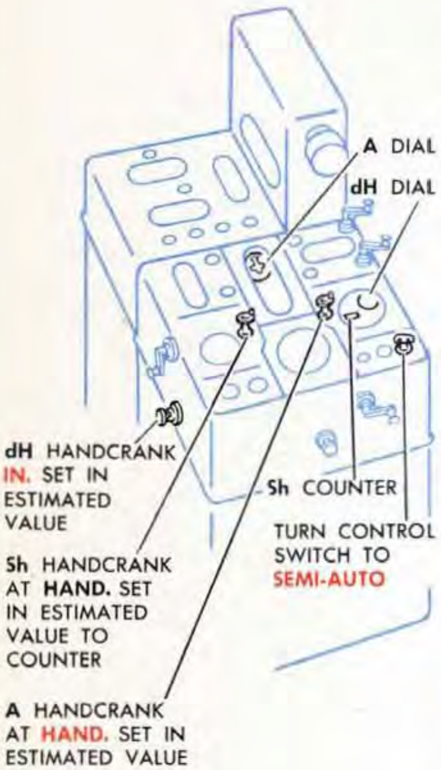
3 When a report of a large change of Target Course is received, leave the Target Angle Handcrank at AUTO. Press one of the buttons on the Target Course Indicator. It is not necessary to hold the Target Speed Switch at INCREASE, but a quicker solution will be obtained if this is done.



If the Target Angle Dial is vibrating, the Target Speed Switch must be held at INCREASE while the Target Angle is being corrected at the Target Course Indicator or after Target Angle is corrected by the Target Angle Handcrank.

MANUAL OPERATION against an Air Target

Changing from standby for an air target to manual operation against an air target



At the Range Station:

1 Turn the Control Switch to SEMI-AUTO.
2 With the Target Speed Handcrank at HAND, set the estimated Target Speed.

At the Elevation Station:

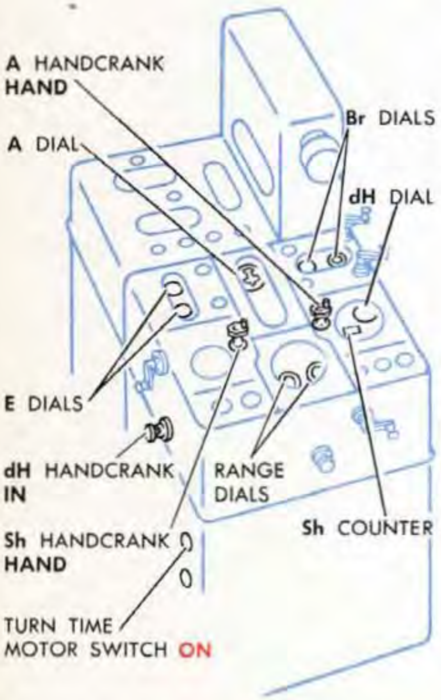
1 With the Rate of Climb Handcrank IN, set the estimated value for *dH* into the Rate of Climb Dial. Leave the handcrank IN.

At the Bearing Station:

1 With the Target Angle Handcrank at HAND, set the estimated Target Angle on the Target Dial. Leave the handcrank at HAND.

Manual control of rates against an air target

In Manual Operation for an air target, the Rate Control Mechanism is not used. Control of rates is handled from the Range and Elevation Stations. The Target Speed, Target Angle, and Rate of Climb Handcranks are used to correct the speed and direction of rotation of the Generated Dials.



At the Range Station:

1 Turn the Time Motor Switch ON.
2 With the Target Angle and Target Speed Handcranks at HAND, make corrections to these values until the Generated Range, Generated Elevation, and Generated Bearing Dials rotate at the same rates and in the same directions as the Observed Range, Observed Elevation, and Observed Bearing Dials.

At the Elevation Station:

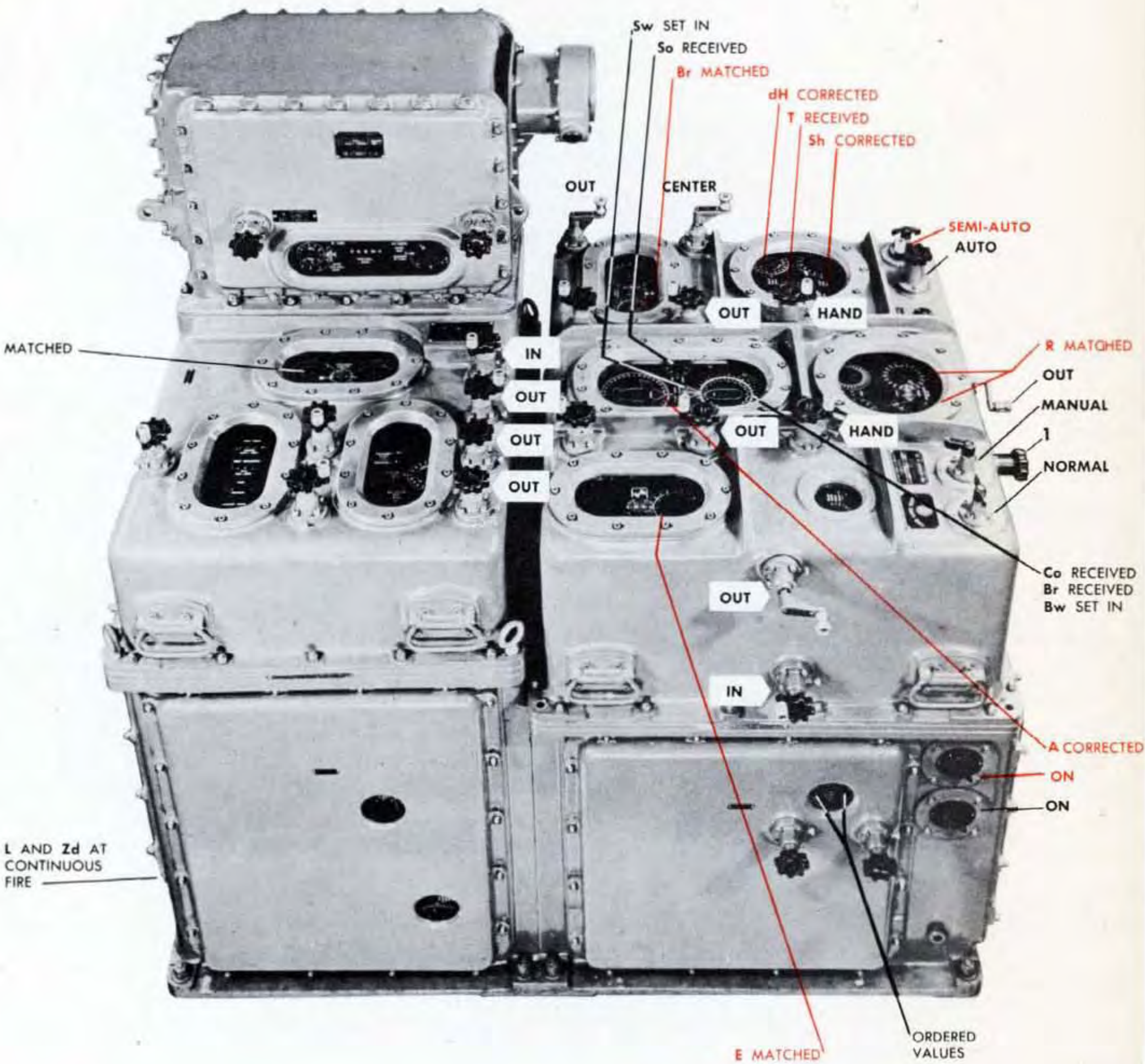
1 With the Rate of Climb Handcrank IN, make corrections to *dH* until the Generated Range and Generated Elevation Dials rotate at the same rates and in the same directions as the Observed Range and Observed Elevation Dials. Corrections to Rate of Climb have little effect on the Bearing Dials.

At the Bearing Station:

1 Stand by for instructions.

Target Elevation, *E*, and Target Angle, *A*, are used to determine which one of the three target values (*Sh*, *A*, or *dH*) to correct.

THE COMPUTER IN MANUAL OPERATION AGAINST AN AIR TARGET

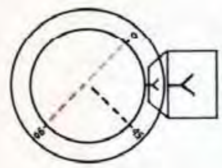


CHANGES FROM STANDBY FOR AN AIR TARGET SHOWN IN RED

CONTROLLING THE GENERATED DIALS IN MANUAL OPERATION

In general, Manual Control of rates against fast-moving air targets is difficult. Knowledge of the fire control problem and practice in Computer operation are necessary because any correction to *Sh, dH* or *A*, usually affects more than one of the generated quantities.

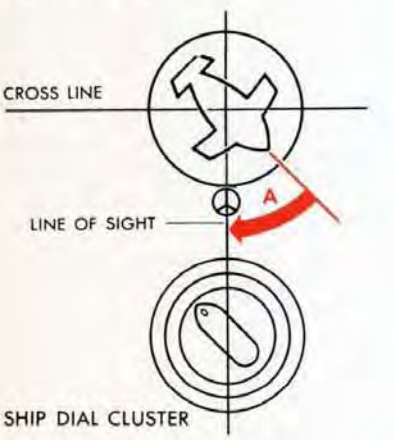
ELEVATION DIAL



While practicing, skill can be acquired by correcting each generated dial in turn, starting with the one showing the most error. In operation, a skilled operator can often correct two or more of the generated quantities at once.

The information which follows describes the correction of each generated quantity separately, by showing the changes in *Sh, dH* or *A* that will have the *greatest* effect on that quantity.

TARGET DIAL

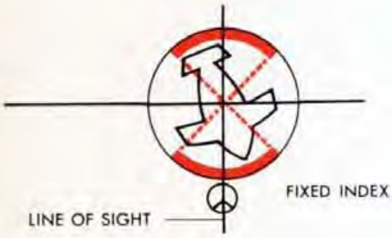


The effect of a change in *Sh, dH* or *A* on the generated dials depends on two things:

1. Target Elevation, *E*, the vertical angle between the Horizontal and the Line of Sight.
2. Target Angle, *A*, the horizontal angle between the direction in which the Target is moving and the Line of Sight.

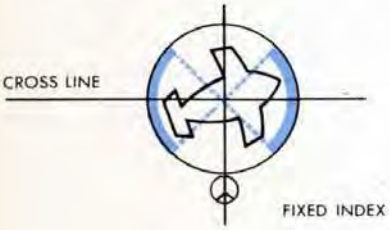
The Target Elevation Dial is divided by an imaginary line into two sections: one section containing values from zero to 45°, and the other section containing values from 45° to 90 degrees.

On the window of the Target Angle Dial, an imaginary line representing the Line of Sight is extended across the dial through the fixed index. Another imaginary line known as the Cross Line is drawn at right angles to the Line of Sight through the center of the Target.



The Target is said to be toward the Line of Sight when the bow of the Target is nearer the Line of Sight.

The Target is said to be toward the Cross Line when the bow of the Target is nearer the Cross Line.



The position of the Target on the Target Dial in relation to the Line of Sight and the Cross Line, together with the value of Target Elevation, determines which Target value has to be changed to control the generated dials in Manual Operation.

A generated dial may be turning in the same direction as the corresponding observed dial, but at a faster or slower speed, or it may be turning in the opposite direction to the observed dial. The instructions which follow give the correction for each of these conditions.

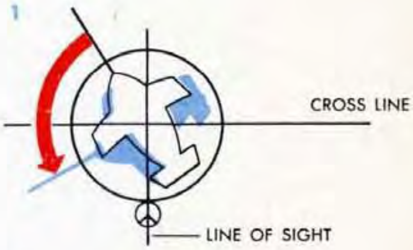
Controlling the generated range dials

When target elevation is below 45° and the target is toward the line of sight

To increase the speed of the Generated Range Dials, increase *Sh*.

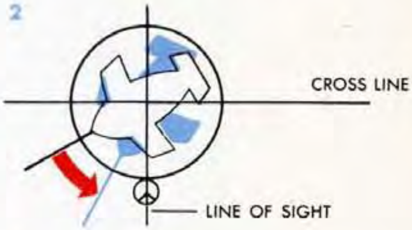
To decrease the speed of the Generated Range Dials, decrease *Sh*.

1 To reverse the direction of rotation of the Generated Range Dials, change *A* until the Target is on the other side of the Cross Line.

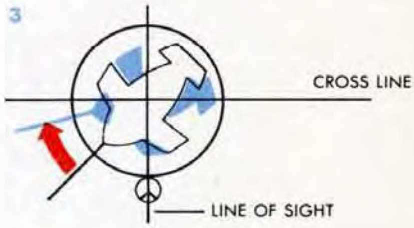
1


When target elevation is below 45° and the target is toward the cross line

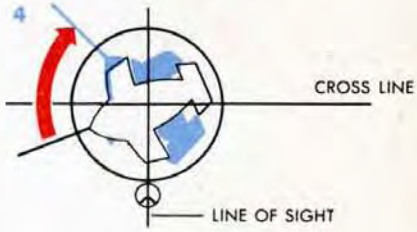
2 To increase the speed of the Generated Range Dials, move the Target away from the Cross Line.

2


3 To decrease the speed of the Generated Range Dials, move the Target closer to the Cross Line.

3


4 To reverse the direction of rotation of the Generated Range Dials, change *A* until the Target is on the other side of the Cross Line.

4


When target elevation is above 45°

To increase the speed of the Generated Range Dials, increase the numerical value of *dH*.

To decrease the speed of the Generated Range Dials, decrease the numerical value of *dH*.

To reverse the direction of rotation of the Generated Range Dials, change *dH* from a positive to a negative, or a negative to a positive value.

Controlling the generated elevation dial in manual operation

When target elevation is below 45°

To increase the speed of the Generated Elevation Dial, increase the numerical value of dH.

To decrease the speed of the Generated Elevation Dial, decrease the numerical value of dH.

To reverse the direction of rotation of the Generated Elevation Dial, change dH from a positive to a negative, or a negative to a positive value.

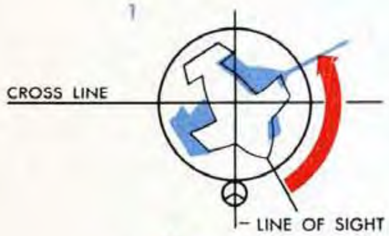
When target elevation is above 45° and the target is toward the line of sight

To increase the speed of the Generated Elevation Dial, increase Sh.

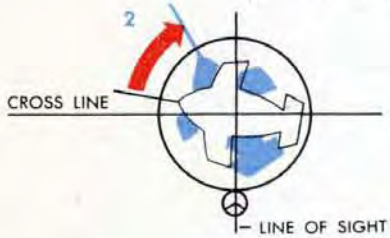
To decrease the speed of the Generated Elevation Dial, decrease Sh.

1 To reverse the direction of rotation of the Generated Elevation Dial, change A until the Target is on the other side of the Cross Line.

1



2



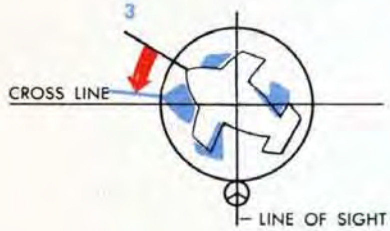
When target elevation is above 45° and the target is toward the cross line

2 To increase the speed of the Generated Elevation Dial, change A to move the Target farther away from the Cross Line.

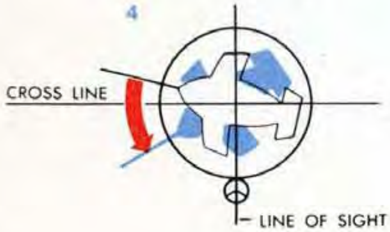
3 To decrease the speed of the Generated Elevation Dial, change A to move the Target closer to the Cross Line.

4 To reverse the direction of rotation of the Generated Elevation Dial, change A until the Target is on the other side of the Cross Line.

3



4

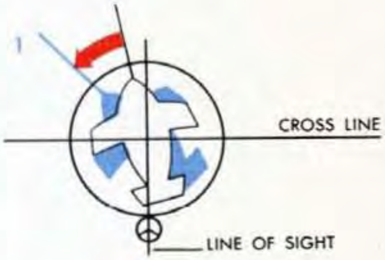


Controlling the generated bearing dial in manual operation

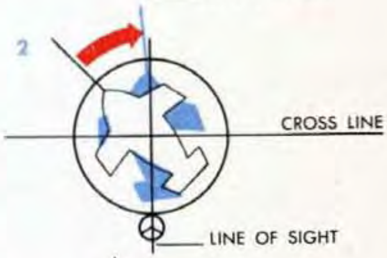
In making corrections to the Generated Bearing Dial, the value of Target Elevation may be disregarded.

When the target is toward the line of sight

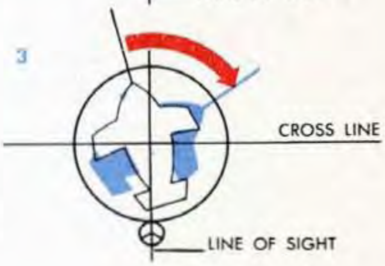
1 To increase the speed of the Generated Bearing Dial, change *A* to move the Target farther away from the Line of Sight.



2 To decrease the speed of tne Generated Bearing Dial, change *A* to move the Target closer to the Line of Sight.



3 To reverse the direction of rotation of the Generated Bearing Dial, change *A* to move the Target to the other side of the Line of Sight.

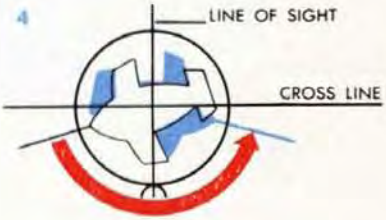


When the target is toward the cross line

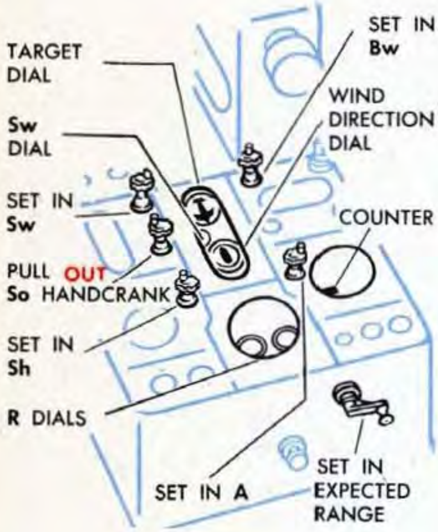
To increase the speed of the Generated Bearing Dial, increase *Sh*.

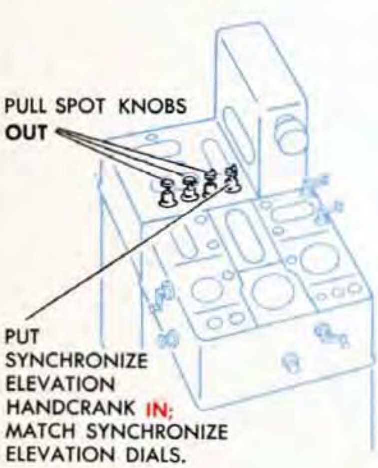
To decrease the speed of the Generated Bearing Dial, decrease *Sh*.

4 To reverse the direction of rotation of the Generated Bearing Dial, change *A* to move the Target to the other side of the Line of Sight.



STANDBY FOR A SURFACE TARGET





Changing from standby during search to standby for a surface target

At the Range Station:

1 With the Generated Range Crank OUT, set the expected Range into the Range Dials. Leave the crank OUT.

2 With the Target Speed Handcrank at HAND, set the estimated *Sh* into the Target Speed Counter. Leave the handcrank at HAND.

At the Elevation Station:

1 With the Rate of Climb Handcrank IN, check that the Rate of Climb Dial is at zero.

2 Set in Wind Speed by turning the Wind Speed Handcrank.

3 With the Ship Speed Handcrank IN, set the approximate speed; then pull the handcrank OUT.

At the Bearing Station:

1 Switch the Target Angle Handcrank to HAND and set in the estimated Target Course or Angle. Leave the handcrank at HAND.

2 Set in Wind Direction by turning the Wind Direction Handcrank.

At the Other Stations:

1 Put the Synchronize Elevation Handcrank IN and match the Synchronize Elevation Dials at the fixed index.

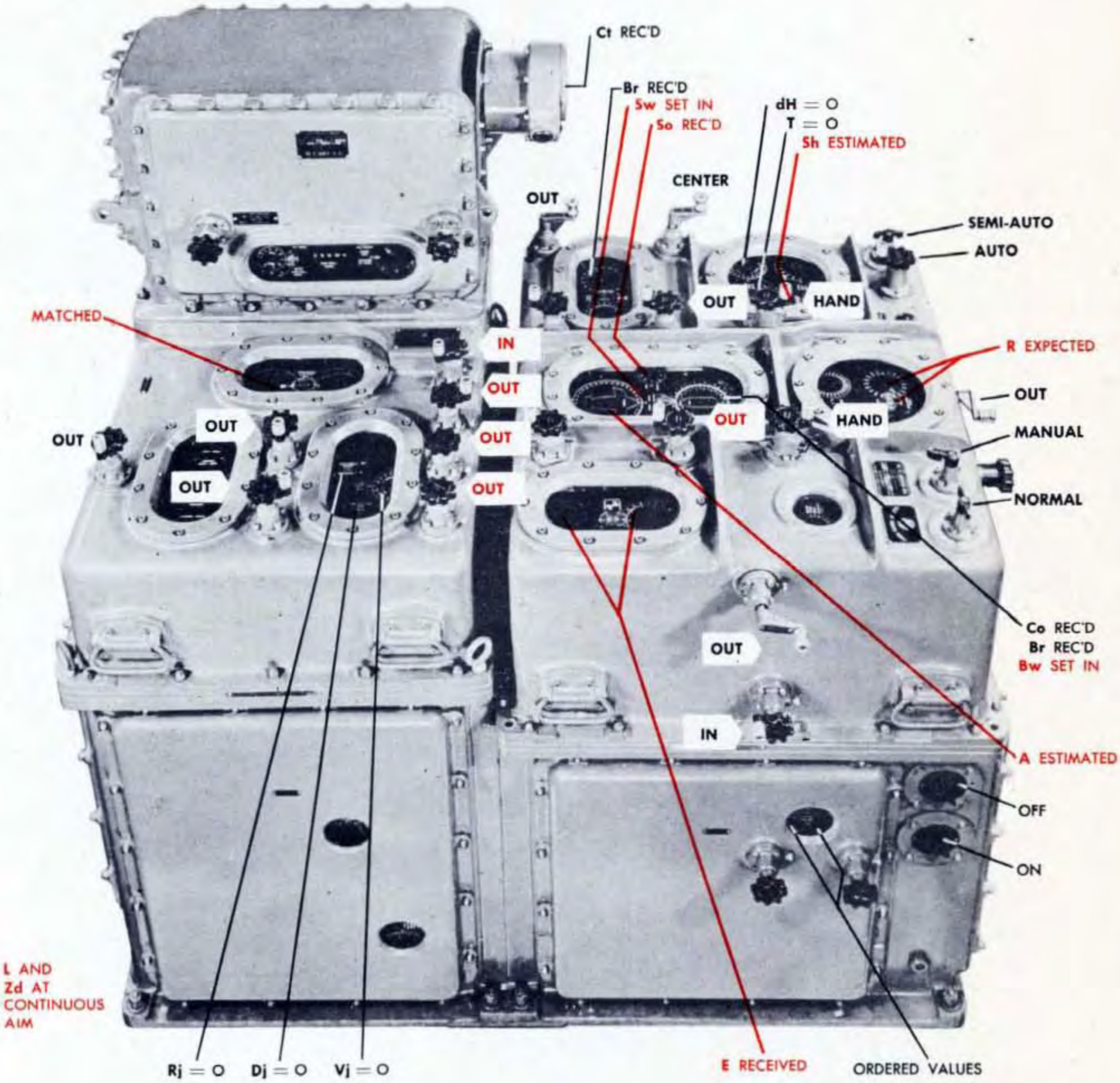
2 Pull the Spot Knobs OUT, noting that correct values of *Rj*, *Vj*, and *Dj* are indicated.

3 Put the Stable Element at Continuous Aim.

4 Make sure that all the switches connecting the Director, the Computer, the Stable Element, and the 5" guns are ON at the Fire Control Switchboard.

When the Range Finder, Pointer's, and Trainer's Signals indicate that the Director is tracking the Target, and the Target comes within tracking range, the Time Motor Switch is turned ON to commence tracking in Manual Operation.

COMPUTER IN STANDBY FOR A SURFACE TARGET



CHANGES FROM STANDBY SHOWN IN RED

MANUAL OPERATION AGAINST A SURFACE TARGET

Changing from standby for a surface target to manual operation against a surface target

At the Range Station:

1 Turn the Time Motor Switch ON.

Rate-controlling in manual operation against a surface target

When Observed Range is correct, the Generated Range Dials must be matched and kept rotating at the same speed. The Generated Bearing Dials must rotate at the same speed as the Observed Dials.

At the Range Station:

1 Use the Target Speed and Target Angle Handcranks to keep the Generated Range and Generated Bearing Dials rotating at the same rates and in the same directions as the Observed Range and Observed Bearing Dials.

Controlling the generated range dials

When the Target is toward the Line of Sight

To increase the speed of the dials, increase *Sh*.
To decrease the speed of the dials, decrease *Sh*.

1 To reverse the direction of rotation of the dials, move the Target to the other side of the Cross Line.

When the Target is toward the Cross Line

2 To increase the speed of the dials, move the Target farther from the Cross Line.

3 To decrease the speed of the dials, move the Target closer to the Cross Line.

4 To reverse the direction of rotation of the dials, move the Target to the other side of the Cross Line.

Controlling the generated bearing dial

When the Target is toward the Line of Sight

5 To increase the speed of the dial, move the Target away from the Line of Sight.

6 To decrease the speed of the dial, move the Target closer to the Line of Sight.

7 To reverse the direction of rotation of the dial, move the Target to the other side of the Line of Sight.

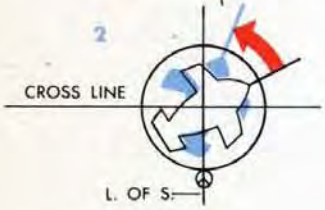
When the Target is toward the Cross Line

To increase the speed of the dial, increase *Sh*.
To decrease the speed of the dial, decrease *Sh*.

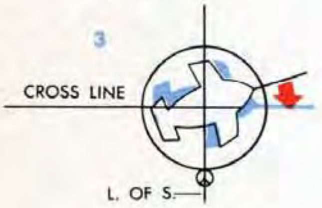
8 To reverse the direction of rotation of the dial, move the Target to the other side of the Line of Sight.

1

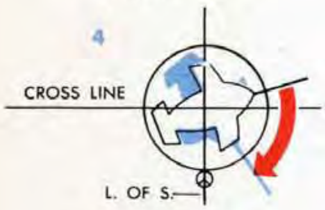
2



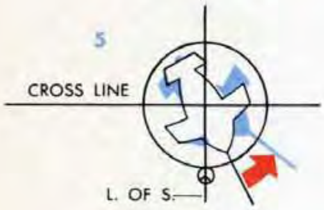
3



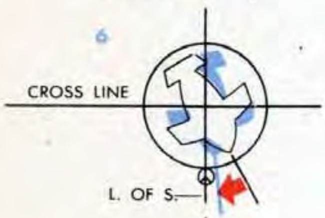
4



5

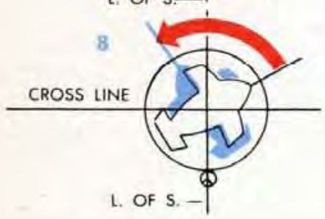


6

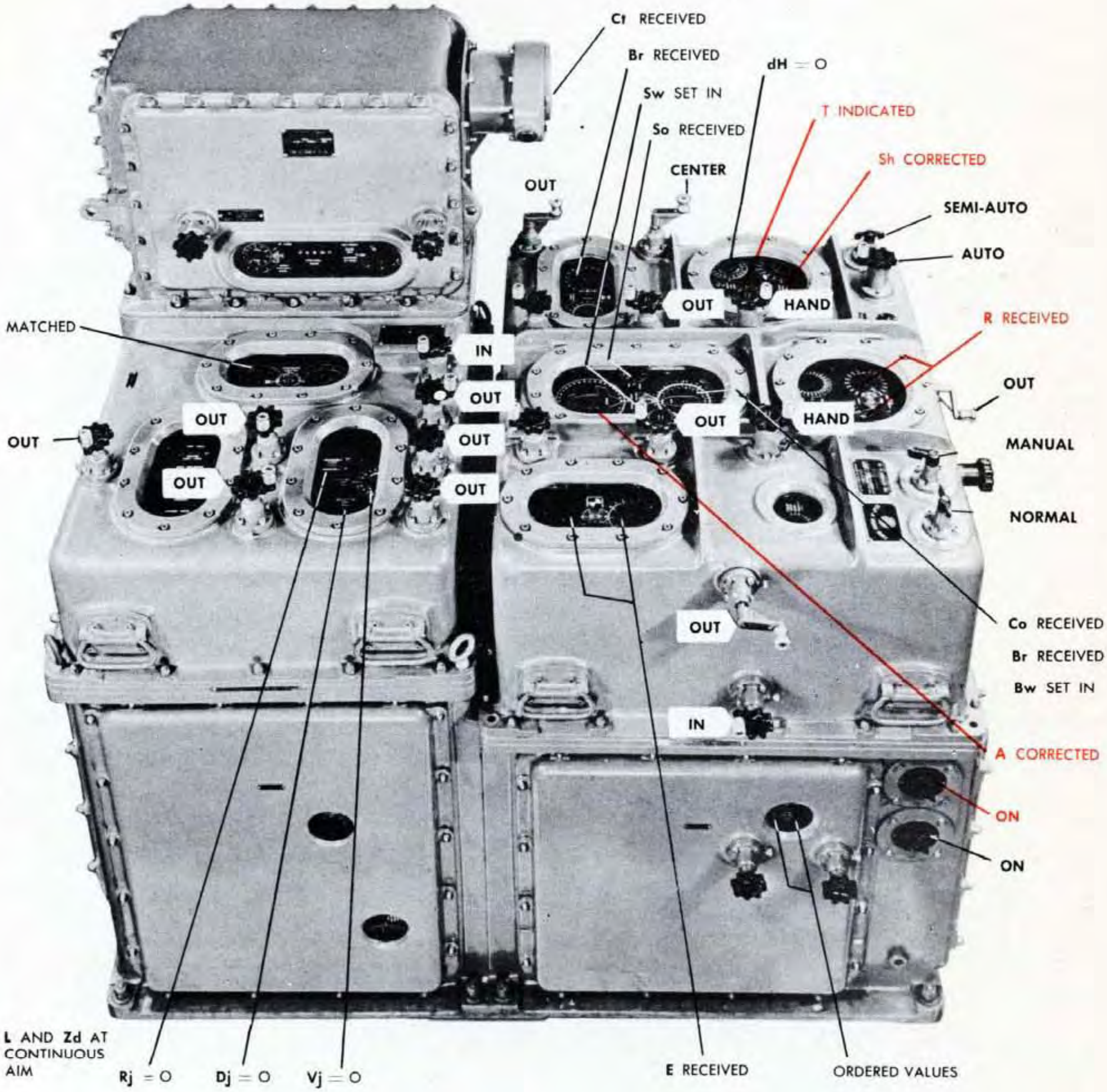


7

8



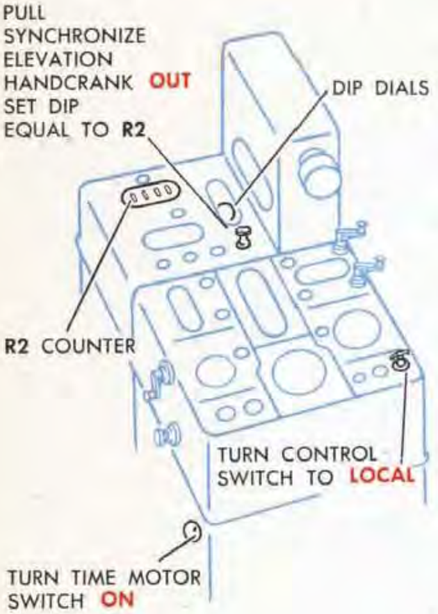
MANUAL OPERATION AGAINST A SURFACE TARGET



CHANGES FROM STANDBY FOR A SURFACE TARGET SHOWN IN RED

LOCAL OPERATION

Local Operation is used against surface targets only, when the Director is not operating, or when specified by ship's doctrine.



Changing from standby for a surface target to local operation

At the Range Station:

1 Turn the Control Switch to LOCAL.

At the Other Stations:

1 Put the Synchronize Elevation Handcrank at CENTER, set the *E* Dials at zero; then pull the Synchronize Elevation Handcrank OUT and set Dip Range into the Dip Dials.

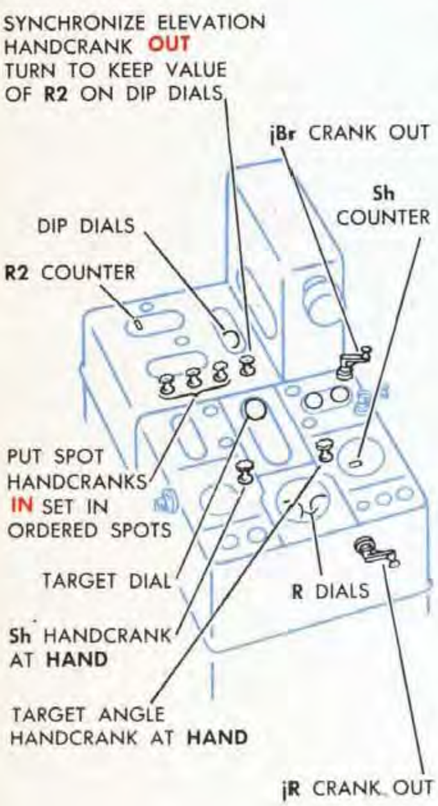
CAUTION: In setting Dip Range into the Dip Dials, be sure that the wide index on the coarse dial is set at the fixed index.

2 Put the Spot Handcranks IN.

To start tracking turn the Time Motor Switch ON.

Tracking in local operation

Range, *R*, Relative Target Bearing, *Br*, Target Angle, *A*, and Target Speed, *Sh*, are continually observed from some point on deck and phoned to the plotting room. The Computer Crew puts these values into the Computer. The Crew then corrects the Target estimates until no further corrections are needed to keep the computed values of Generated Range and Bearing shown on the dials equal to the phoned values of Range and Bearing.



At the Range Station:

1 With the Generated Range Crank OUT, set the phoned values of Range into the Generated Range Dials.

2 With the Target Speed and Target Angle Handcranks at HAND, correct *Sh* and *A* until the Range and Bearing Dials turn in agreement with the phoned values.

At the Bearing Station:

1 With the Generated Bearing Crank OUT, set the phoned values of Bearing into the Bearing Dials.

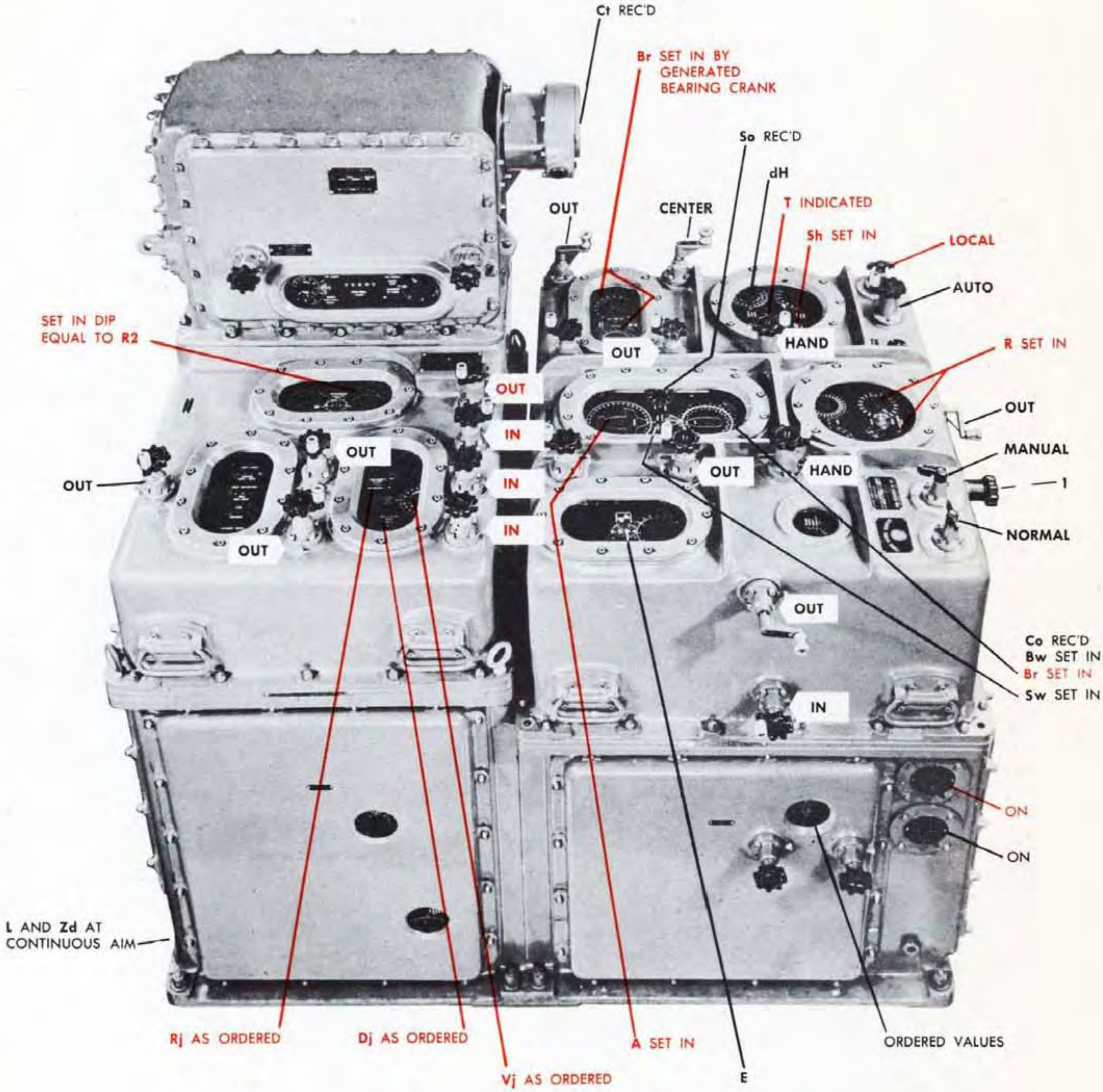
At the Other Stations:

1 Turn the Synchronize Elevation Handcrank in the OUT position to keep the value of Dip Range on the Dip Dials in agreement with the Advance Range reading on the *R2* Counter. (*R2* is used instead of *cR* for convenience in setting the Dip Range.)

2 With the Spot Handcranks IN, set in any Spot Corrections that are ordered.

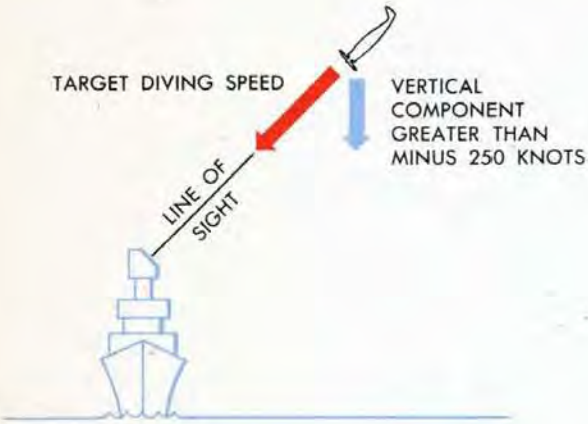
The problem is solved when no further Target value corrections are necessary to keep the values of Range and Bearing shown on the dials in agreement with the phoned values.

THE COMPUTER IN LOCAL OPERATION

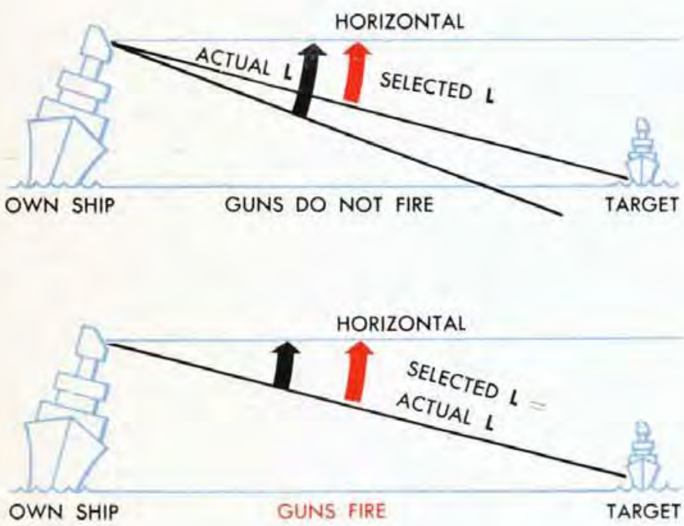


CHANGES FROM STANDBY FOR A SURFACE TARGET SHOWN IN RED

Summary of SPECIAL TYPES OF OPERATION

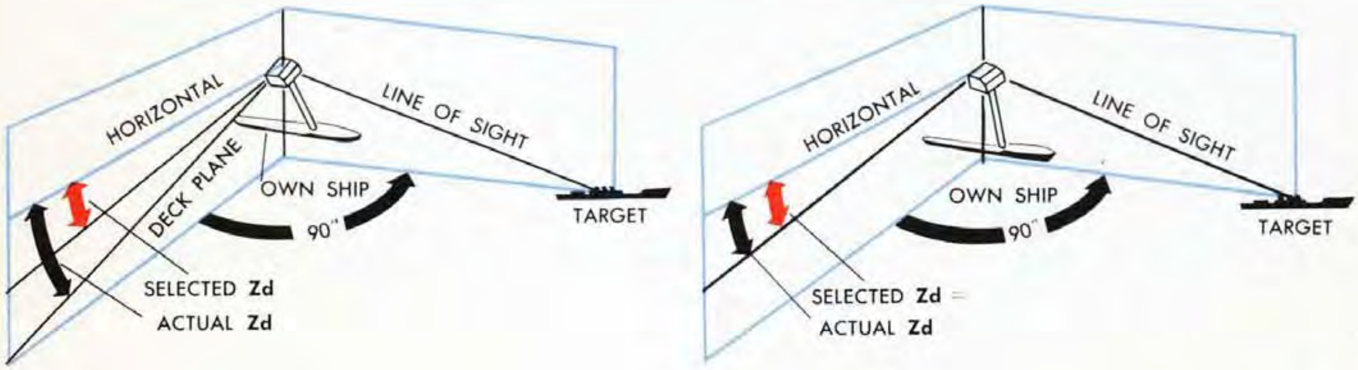


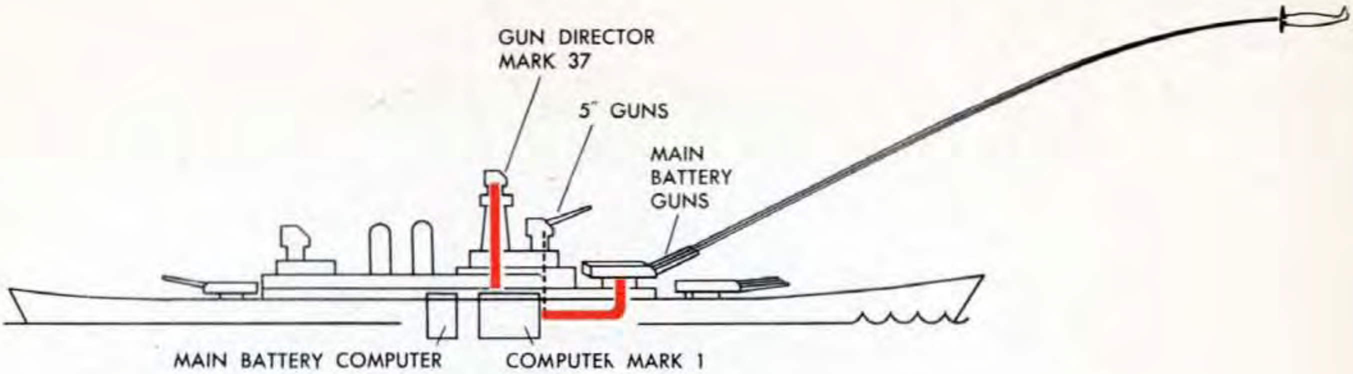
Special Dive Attack Procedure is a special type of operation used against air targets diving at Own Ship along the Line of Sight. Special Dive Attack Procedure is necessary only when the vertical component of dive is greater than −250 knots.



Selected Level Fire, Level Angle selected at the Director, is a method of operation used against surface targets when Continuous Aim cannot be used. The Pointer in the Director selects a fixed value of Level and fires the guns when actual Level equals the Selected Level. If the Director is not operating, the Selected Level is set at the Stable Element, and the firing of the guns is handled by the Stable Element Crew.

Selected Cross-level Fire also is used only against surface targets when Continuous Aim cannot be used. Selected Cross-level is always set at the Stable Element, and the firing of the guns is handled by the Stable Element Crew.





Main Battery Barrage Fire is a method of operation that permits the use of the main battery guns against on-coming aircraft. The normal outputs of the Computer Mark 1 are corrected by spots to compensate for the difference in ballistics between the 5" guns and the guns in the main battery.

Star Shell Fire is used at night to illuminate surface targets. A star shell bursts 1500 feet above and 1000 yards beyond the Target. When the shell bursts, it releases a parachute flare that burns for sixty seconds. A deflection correction is required to place the flare directly on the Line of Sight behind the Target after the flare has burned for thirty seconds.

A Star Shell Computer is mounted on the right side of the top of the Computer Mark 1. The Star Shell Computer receives data from the Computer and adds the corrections that are needed to place the star shell above and beyond the Target. The Star Shell Computer outputs are electrically transmitted to any one gun used to fire the star shells. The firing of the star shells does not interfere with the firing of service shells by the other guns. When a Star Shell Computer is not supplied, a Star Shell Legend Plate is mounted in its place. This legend plate gives the values of Sight Angle and Fuze Setting Order required for different values of Advance Range. These values are phoned to the gun used to fire the star shell.

DIVE ATTACK AGAINST OWN SHIP

DIVE ANGLE	DIVING SPEED FOR MAX. dH OF 250 KNOTS
90°	250
80°	254
70°	266
60°	289
50°	326
40°	389

The type of Computer operation used against diving aircraft depends on the nature of the dive attack.

In Auto or Semi-auto Operation

When Vertical Target Speed, *dH*, is numerically less than −250 knots, dive attacks against Own Ship can be handled by the Computer in Automatic or Semi-automatic Operation.

SPECIAL DIVE ATTACK PROCEDURE

When the *dH* Dial reaches −250 knots, SPECIAL DIVE ATTACK PROCEDURE must be used against Targets diving at Own Ship.

Changing to Special Dive Attack Procedure

At the Range Station:

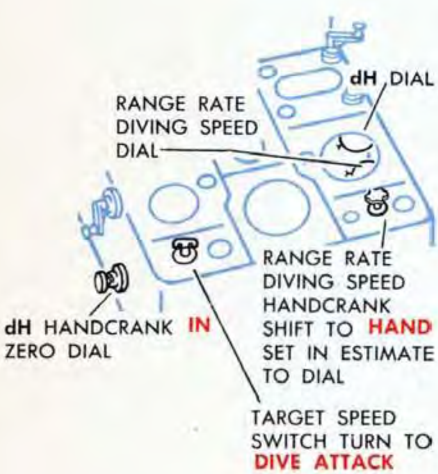
1 Turn the Target Speed Switch to DIVE ATTACK and leave it there.

2 Shift the Range Rate/Diving Speed Handcrank to HAND. Set the estimated Diving Speed into the Diving Speed Dial.

At the Elevation Station:

1 Put the Rate of Climb Handcrank IN. Zero the Rate of Climb Dial. Leave the handcrank IN.

Rate-controlling in Special Dive Attack Procedure



At the Range Station:

1 With the Range Rate/Diving Speed Handcrank at HAND, continue correcting the Diving Speed estimated until the Generated Range Dials turn at the same rate as the Observed Range Dials and remain matched at the same value.

At the Elevation Station:

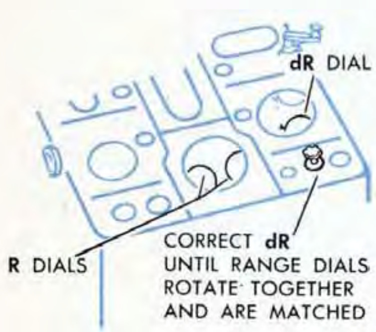
1 The Elevation Dials remain almost stationary because the Target is coming down the Line of Sight.

At the Bearing Station:

1 Any movement of the Bearing Dials is due to motion of Own Ship.

The solution is reached when the Generated Range, Elevation, and Bearing Dials rotate at the same rate as the Observed Range, Elevation, and Bearing Dials.

As soon as the Dive Attack order is over, turning the Target Speed Switch to NORMAL returns the Computer to Automatic Operation. Put the Range Rate/Diving Speed Handcrank at AUTO.



DIVE ATTACK AGAINST OTHER SHIPS

No special procedure is available for dive attack against other ships, regardless of the diving speed. The Computer should be placed in Automatic or Semi-automatic Operation.

SPECIAL DIVE ATTACK PROCEDURE CANNOT BE USED AGAINST PLANES DIVING AT OTHER SHIPS.

SELECTED LEVEL FIRE

Selected Level Fire is used only against surface targets. The guns can be fired only when the deck has tilted to the Selected Level Angle.

There are two types of Selected Level Fire: one in which the Selected Level is set by the Pointer in the Director, and another in which the Selected Level is set at the Stable Element. The second type is almost always used, and must be used when the Director is not operating.

WHEN LEVEL IS SELECTED AT THE DIRECTOR, the operation of the Computer is exactly the same as for regular Manual Operation against a surface target, except that the Synchronize Elevation Handcrank is put in the CENTER position and the Elevation Dials are set at zero.

The Pointer fires the guns whenever his crosshair is on the Target.

NOTE:

The Director Mark 37 is not well adapted to Selected Level Fire from the Director because the Trainer's and Range Finder Optics and the Radar Antenna cannot be elevated independently of the Pointer's Optics. When the Pointer's Line of Sight swings off the Target the Trainer's and Range Finder Optics and the Radar beams also swing off the Target. This makes ranging and training impossible under most conditions.

WHEN LEVEL IS SELECTED AT THE STABLE ELEMENT, the operation of the Computer is exactly the same as for either regular Manual or Local Operation, except that Dip is set in by the Synchronize Elevation Handcrank in the OUT position.

The Stable Element Crew puts the Stable Element firing selector lever at SELECTED LEVEL position and selects the value of Level desired. Either AUTO or HAND firing can be used. Whenever the deck tilts so that the actual Level equals the Selected Level, the firing contacts complete the firing circuit allowing the guns to be fired.

SELECTED CROSS-LEVEL FIRE

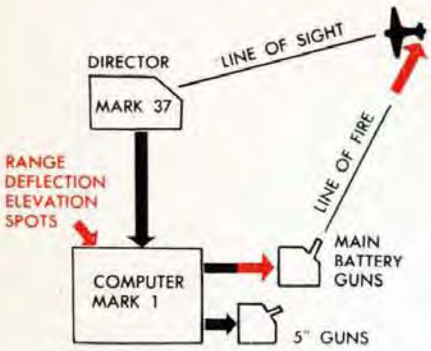
Selected Cross-level Fire is used only against surface targets. The guns can be fired only when the deck has tilted to the selected value of Cross-level.

Selected Cross-level Fire can be used with or without the Director. The Cross-level value is always selected at the Stable Element. The guns can be fired whenever the Stable Element firing contacts complete the firing circuit.

WITH THE DIRECTOR, the Computer is operated for Selected Cross-level Fire in Manual Operation.

WITHOUT THE DIRECTOR, the Computer is operated for Selected Cross-level Fire in Local Operation.

MAIN BATTERY OPERATION



Many of the Directors and Computers controlling main battery guns solve surface problems only. By using the Gun Director Mark 37 and the Computer Mark 1, the main battery guns can be adapted for barrage fire against on-coming aircraft.

The Computer Mark 1 normally computes solutions for the 5″ guns. These solutions can be adapted to main battery guns by the addition of the proper Range, Deflection, and Elevation Spot Corrections for each size of gun and projectile.

The spots that are required are given in a Table of Corrections for each size of gun. A Table of Corrections looks like this:

SAMPLE TABLE OF CORRECTIONS

4000 FEET
TARGET HEIGHT

MIN. OBS. RANGE	FUZE	RANGE SPOT IN	ELEV. SPOT DOWN	DEFL. SPOT RIGHT
12400	15	1080	16	0
12900	16	1140	17	1
13400	17	1190	18	1
13900	18	1250	20	1
14400	19	1310	21	1
14900	20	1370	23	1
15400	21	1421	25	1

OD 5102

This table is a sample and does not apply to any particular combination of gun and computer.

The Director Mark 37 and Computer Mark 1 track the Target by the same methods used when controlling the 5″ guns. The guns are elevated and trained continuously by the Mark 1 Gun Orders. The Parallax Corrections are not used.

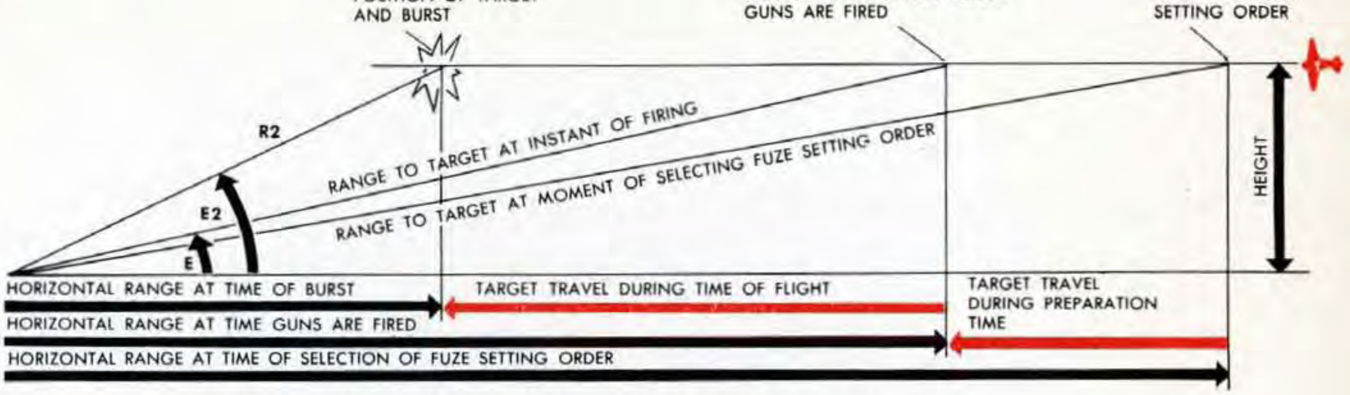
When a solution is reached, the Spot Corrections that are shown on the Table are applied. A Fuze Setting Order is selected and phoned to the guns. The guns are fired when the computed Fuze Setting Order equals the Selected Fuze Setting Order.

When the Computer Mark 1 is used for main battery operation, its solution can be used by only one size of gun and projectile at any one firing. If the 5″ guns are to be fired in the same barrage as the main battery guns, a separate Computer Mark 1 is required to operate the 5″ guns, because the Spot Corrections made to suit the main battery guns would place the 5″ gunbursts short of the Target.

Quick Reference Index

Using a TABLE OF CORRECTIONS

The Table of Corrections is based on one problem: a Target flying at a constant speed, at a constant height, directly toward Own Ship.

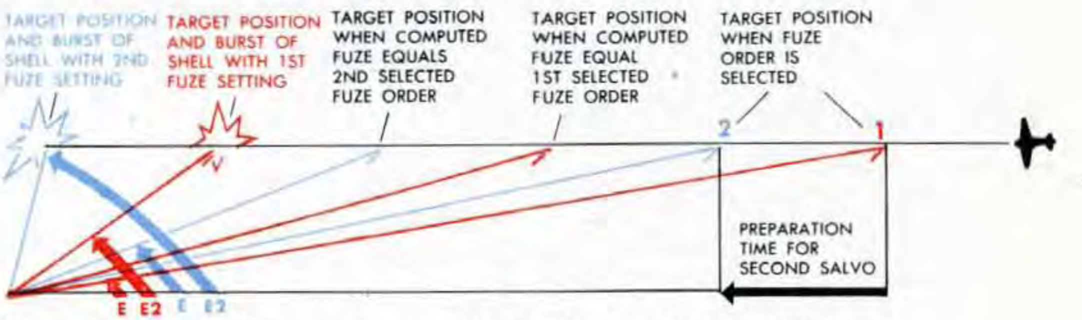


The guns are fired at a Selected Fuze Setting Order determined by the Target Height and Range. The Height of the Target is obtained from the Computer Height Dials. The Observed Present Range is obtained from the Generated Range Dials. After the Height and the Present Range are determined, a Minimum Observed Range is obtained from the table that is *less* than the Computer Range Dial reading. This allows for Target Motion between the time of selecting the Fuze Setting Order and the firing of the guns.

The Selected Fuze Setting Order depends on the Minimum Observed Range obtained from the table. In the column headed "Fuze," next to the column headed "Min. Obs. Range," is the value of the Selected Fuze Setting Order for the particular Height and Range of the Target. This Selected Fuze Setting Order is phoned to the guns.

The Range, Deflection, and Elevation Spots given in the table are set into the Computer to adapt its outputs to the ballistics of the main battery guns. With the Spots entered, the guns are fired as soon as the Fuze Setting Order transmitted from the Computer equals the Selected Fuze Setting Order previously phoned.

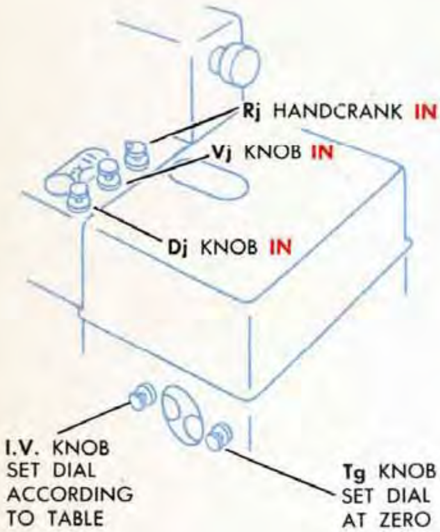
Using alternate tables



Two tables may be used to permit the firing of two salvos in close succession. Using this method, two Fuze Setting Orders are selected for two different ranges. The first range is longer than the second by a time sufficient to allow for the preparation of the guns for the second salvo.

THE MAIN BATTERY CONTROL

Changing from standby for an air target to main battery control



At the Range, Elevation, and Bearing Stations:

1 Make the changes required to go into Automatic, Semi-automatic, or Manual Operation.

At the Other Stations:

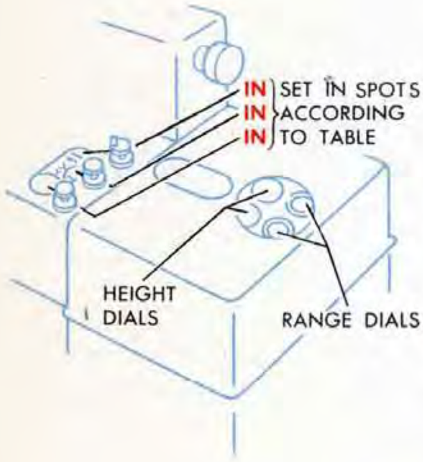
1 At the Fire Control Switchboard, connect the Gun Director Mark 37 and the Computer Mark 1 to the main battery guns.

2 Set the Dead Time Dial at zero.

3 Set the Initial Velocity Dial at a value that is equal to the actual *I.V.* of the main battery guns minus the value given on the Table of Corrections.

4 Put the Range Spot Handcrank and the Deflection and Elevation Spot Knobs IN.

The computer is then operated in automatic, semi-automatic or manual control until a solution is reached



After the solution is reached:

1 Read the Height Dials. Apply this value to the nearest thousand feet on the Table of Corrections.

2 Read the Range Dials. Select a Fuze Setting Order on the Table of Corrections for a shorter Range than is shown on the Range Dials.

3 Phone the Selected Fuze Setting Order to the guns, and at the same time,

4 Set in the Range, Deflection, and Elevation Spots given in the Table of Corrections for the Selected Fuze Setting Order.

At the Computer, the Fuze Setting Order Counter is watched carefully. The instant that the Fuze Setting Order Counter reading equals the phoned Selected Fuze Setting Order, the guns are fired.

STAR SHELL FIRE

Star Shell Fire is controlled in three ways:

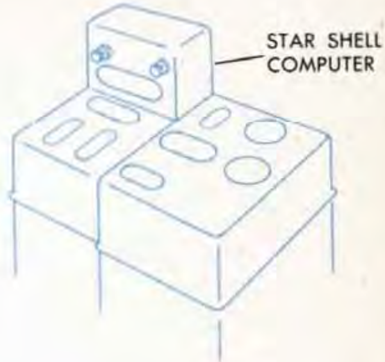
1 By the Star Shell Computer Mark 1.

2 By orders for Fuze and Sight Angle taken from the Star Shell Legend Plate and phoned to the guns.

3 By orders for Fuze and Sight Angle taken from the Star Shell Legend Plate and transmitted to the guns through the Computer Mark 1.

THE STAR SHELL COMPUTER

The Star Shell Computer is mounted on the top of the Computer Mark 1.



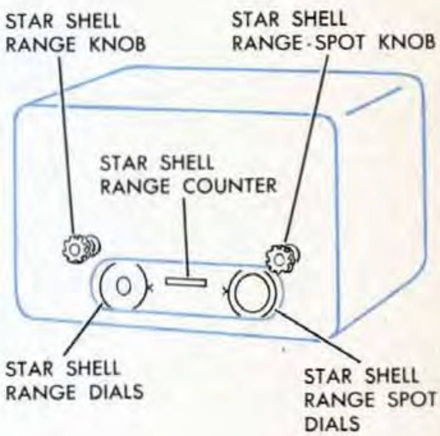
Operating the star shell computer

1 At the Fire Control Switchboard, connect the Star Shell Computer to the gun that is to fire the star shells.

2 Turn the Star Shell Range Spot Knob to match the index on the Range Spot Ring Dial with the arrow on the inner dial.

3 Push the Star Shell Range Knob IN and set the inner Star Shell Range Dial to the Star Shell Counter reading. Pull the knob OUT and set the ring dial to the counter reading. Return the knob to its IN position.

CAUTION: The transmission system of the Star Shell Computer is designed to control only one gun.



THE STAR SHELL LEGEND PLATE

When there is no Star Shell Computer, a Star Shell Legend Plate is attached to the Computer Mark 1 in its place.

The Legend Plate has four columns. The first column shows Advance Range at intervals of 2,000 yards, from 4,000 to 14,000 yards. The next two columns show the Fuze Setting Orders for powder and mechanical fuzes corresponding to the values of Advance Range given in the first column. The last column lists the values of Sight Angle corresponding to the values of Advance Range in the first column.

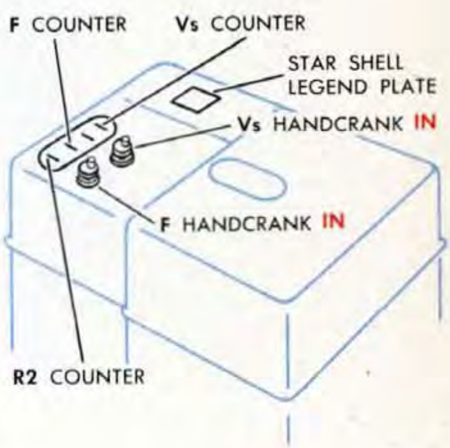
STAR SHELL DATA FOR 2500 F.S. I.V.

ADV. RANGE	FUZE PWDR.	FUZE MECH.	SIGHT ANGLE
4000	11	8	2570
6000	16	13	2630
8000	22	19	2800
10000	29	27	3050
12000	35	35	3400
14000	42	45	3880

Using the legend plate

1 Read the Advance Range Counter on the Computer. Apply this value to the Advance Range Column of the Star Shell Legend Plate.

2 Read the Fuze Setting Order and Sight Angle values appearing opposite the Advance Range selected, and phone these values to the gun firing the star shells, or if the 5″ battery is being used to fire star shells only, send the Fuze and Sight Angle data to the guns by setting the values into the Computer Mark 1. To do this, put the Fuze and Sight Angle Handcranks IN and turn them until the values designated on the Star Shell Legend Plate show on the Fuze and Sight Angle Counters on the Computer.



ALTERNATIVE STANDBY CONDITIONS

The following Standby Conditions may be used when great speed is needed in shifting to full operation.

Standby Condition

All the Computer, Stable Element, Director, and gun transmission circuits are energized.

The Stable Element Level and Cross-level Switches are at MANUAL.

The Selector Drive is in LOCK position.

At the Computer:

1 The Power Switch is ON.
2 The Ship Course Handcrank is IN.
3 The Control Switch is at SEMI-AUTO.
4 The Range Rate Control Switch is at MANUAL.
5 The Ship Speed Handcrank is OUT, with *So* synchronized.
6 The Time Motor is OFF.

NOTE:
To eliminate constant setting of fuzes in the bottom of the projectile hoist, the Fuze Handcrank on the Computer may be locked in its IN position with Fuze set at 2 seconds.

Standby during search

When Search begins, turn the Stable Element Level and Cross-level Switches to AUTO.

At the Computer:

1 Pull the Ship Course Handcrank OUT.
2 Pull the Fuze Handcrank OUT.

NOTE:
The only time the Selector Drive should be unlocked is when the equipment is in a Standby Condition and Own Ship is rolling more than 20 degrees. Under these conditions the Stable Element Level and Cross-level Switches must be at AUTO to prevent tumbling of the gyro. The plotting room crew must be alerted to shift to LOCK when Search begins.

Changing from standby during search to air target expected

At the Range Station:

1. Switch the Target Speed and Target Angle Handcranks to AUTO.
2. With the Target Speed Switch, set *Sh* at approximately 200 knots.
3. With the Generated Range Crank OUT, match Generated Range to Observed Range.
4. Turn the Time Switch ON.
5. Switch the Target Speed Handcrank to HAND.
6. Turn the Control Switch to AUTO.
7. After approximately 2 seconds, switch the Target Speed Handcrank back to AUTO. This may be done by the Elevation Operator while the Range Operator keeps the Range Dials matched.
8. Report "Plot set."
9. Push the Generated Range Crank IN. Press the Range Rate Manual Push-button and keep the Range Dials matched.

At the Elevation Station:

1. Put the Synchronize Elevation Handcrank IN and match the Synchronize Elevation Dials.
2. Set Rate of Climb on zero and pull the Rate of Climb Handcrank OUT.
3. Pull the Spot Knobs OUT.

At the Bearing Station:

1. At the Target Course Indicator, set Target Course as ordered.

A SAMPLE PROBLEM

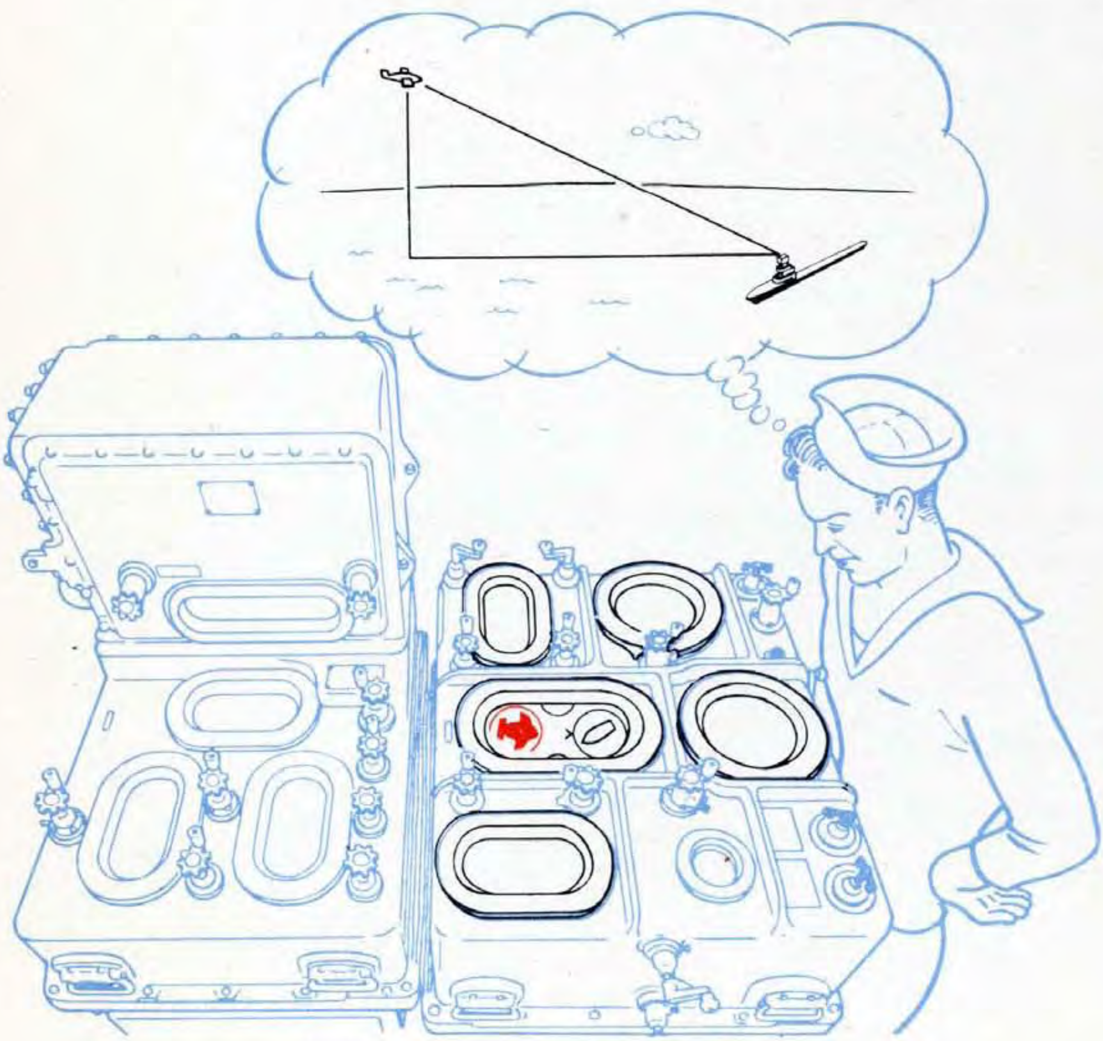
A man standing in the plotting room watching the Fire Control Switchboard and the Computer Mark 1 can obtain a very accurate picture of the fire control problem and of the activity throughout the Gun Director Mark 37 System.

The positions of the switches on the Fire Control Switchboard and the Computer show him the condition of the Computer relative to the other parts of the fire control system.

The positions and motion of the Computer dials give a good picture of the actual conditions existing between Own Ship and Target.

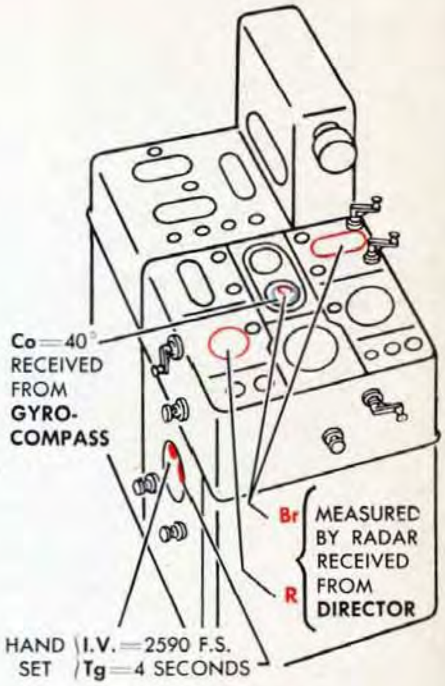
Indicating signals from various parts of the system show the action being taken there.

This chapter describes a sample fire control problem. It is not a typical combat problem but is designed to show how the action above deck can be visualized in the plotting room.



Action is expected

At the start of this problem, the switches on the Fire Control Switchboard and the Computer show that the Computer is in *Standby during Search. Standby during Search* usually indicates that action is expected.



At the Computer, Own Ship Course is being received from the Gyro Compass. The Compass Ring Dial reads 40° against the zero index of the Ship Dial. The only other dials showing actual values are the Initial Velocity Dial, which has been set at 2590 f.s., and the Dead Time Dial, which has been set at 4 seconds.

The Radar Range Dial and Relative Target Bearing Dials are moving, showing that the Director is searching for a target.

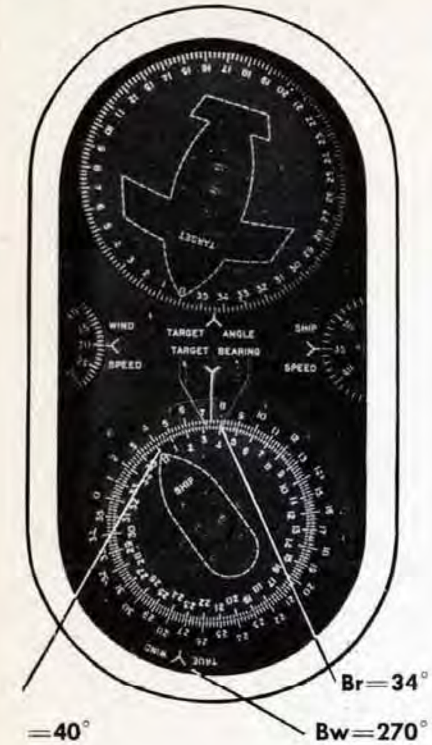
After a few moments the Radar Range Dial and Relative Target Bearing Dials steady down and move gradually, indicating that radar search has picked up a target. The Radar Range Dial shows a little under 75,000 yards.

The Bearing Dials steady down around 34 degrees.

There is no reading for Target Elevation because the Director Elevation Receiver is not yet energized at the Fire Control Switchboard.

The reading on the Radar Range Dial is decreasing, showing that the Target is approaching Own Ship. The high rate at which the reading is decreasing indicates an air target.

The problem so far can be visualized like this:



An air target is expected

The Computer is ordered to *Standby for an Air Target*. The Range Dials are set at 35,000 yards, the maximum Range at which the Computer can start tracking.

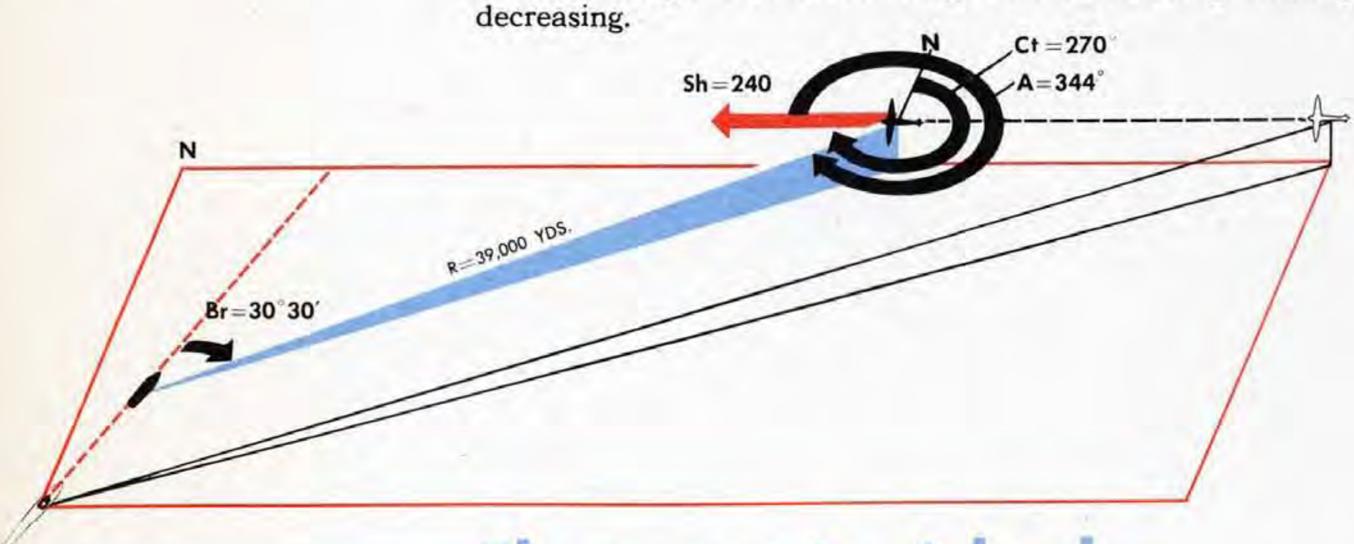
The Ship Speed Dial now shows 35 knots. The value of this quantity is being received from the Pitometer Log. Own Ship Course still reads 40 degrees.

Reports of Wind Direction and Wind Speed are now received. *Bw* is quickly set at 270°, *Sw* at 20 knots.

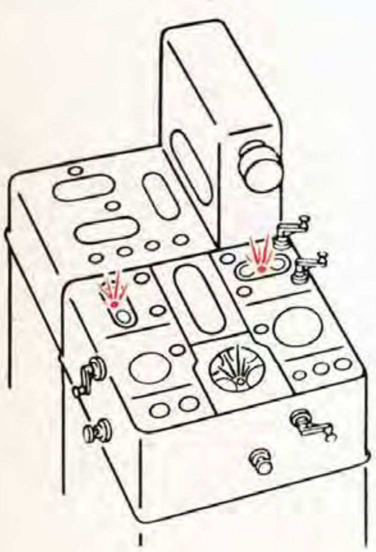
A moment later, estimates of Target Course and Target Speed are received by phone. *Ct* is set at 270° and *Sh* is set at 240 knots. *dH* is set at zero. According to these estimates, the Target is heading due West, flying at a steady altitude. The position of the Target in relation to Own Ship can now be seen on the Ship and Target Dials.

The Director Elevation Receiver is now energized and *E* can be read on the *E* Dials.

The Ship, Compass, and True Wind Dials, and the Observed Relative Target Bearing Dials turn slowly as Relative Target Bearing changes. The Radar Range Dial shows Range steadily decreasing.



The target is sighted



When Range has closed to less than 39,000 yards, and *Br* is 30° 30′, the Trainer's Signal turns to red. The Trainer now has his crosshair on the Target.

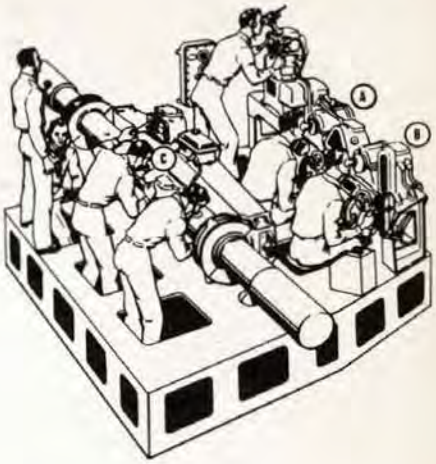
A few seconds later the Pointer's Signal also turns to red. Now the Pointer has his crosshair on the Target.

The Range Finder Signal turns to white, showing that the Range Operator in the Director has the Target in focus.

For a while all three signals from the Director continue to show these colors, indicating that the sights are being held on the Target by the Director Operators.

With the Director Sights and Range Finder on the Target, and all the necessary information available, tracking can be started at the Computer the moment that Range reaches 35,000 yards.

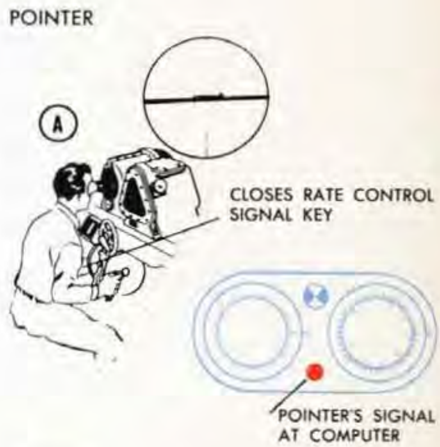
Reviewing the signals and indicators in automatic operation



When the Computer is in Automatic Operation, the signals and solution indicators play a large part in visualizing the Gun Director operation. Because the Computer may be ordered into Automatic Operation when the maximum tracking range is reached, it is well to review the function of these controls.

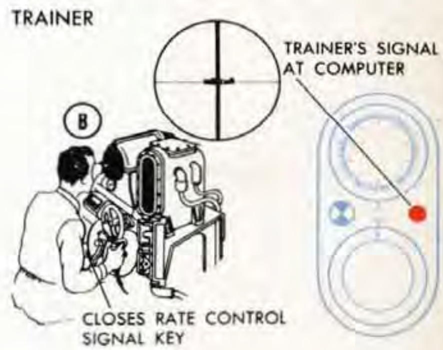
Elevation

The Pointer closes his signal key and causes the Pointer's Signal at the Computer to show red whenever his crosshair is on the Target. If the Elevation Solution Indicator rotates while the Pointer's Signal is red, the Pointer is putting angular and rate corrections to Elevation into the Computer. If the Indicator rotates while the Signal is black, the Pointer is putting in angular corrections only.



Bearing

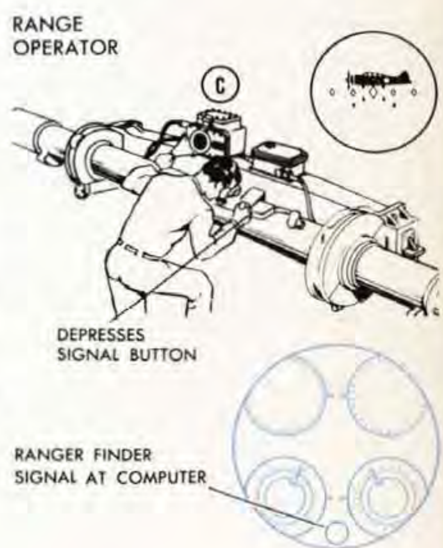
The Bearing Solution Indicator and the Trainer's Signal have the same relationship to Bearing corrections as the Elevation Solution Indicator and the Pointer's Signal have to Elevation corrections.



Range

The Range Operator depresses his signal button and causes the Range Finder Signal at the Computer to show white whenever the Range is correct. If the indexes on the Generated Range Dials are not matched to those on the Observed Range Dials at the time that the signal turns to white, the Generated Range Dials immediately turn until the indexes match. A linear and a rate correction to Range are made automatically.

If the indexes on the Range Dials are already matched at the time that the Range Finder Signal turns to white, no corrections are made to Range.



TRACKING BEGINS

When the Radar Range Dial reads 35,000 yards and Range is coming in smoothly and accurately, the Computer is ordered into Automatic Operation. The Control Switch and the Range Rate Control Switch are set at AUTO and the Time Switch is turned ON. The Generated Range, Elevation, and Bearing Dials spin and then synchronize with their Observed Dials.

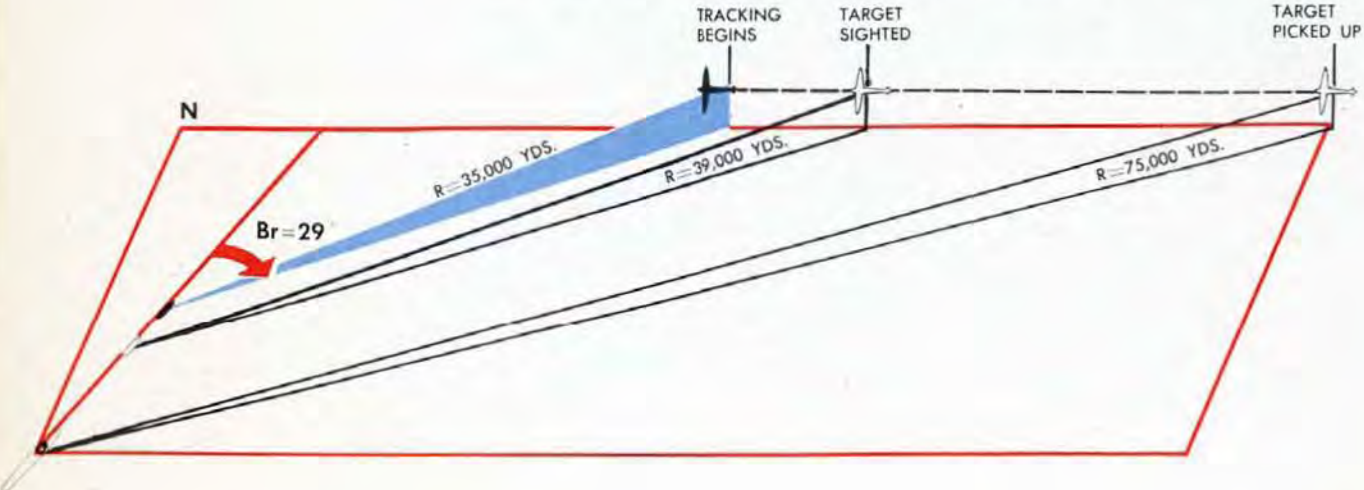
The sights are kept on target

As the Elevation Dials synchronize, the Pointer's Signal turns to black, showing that the Pointer's crosshair has moved off the Target. The Elevation Solution Indicator rotates as the Pointer turns his handwheels and sets in a correction to Elevation. The Pointer's Signal turns to red as the Indicator turns, showing that the Pointer is now setting in both angular and rate corrections to Elevation. After a moment the Indicator stops turning, and the Signal remains red. The Generated Changes of Elevation are now raising the Director sights at the correct rate to keep the Pointer's crosshair on the Target.

The Trainer's Signal remains red as the Computer is put into Automatic Operation. The Bearing Solution Indicator remains stationary, indicating that the Generated Changes of Director Train are training the Director correctly, and no rotation of the Trainer's handwheels is required to keep the Trainer's crosshair on the Target.

With Range just under 35,000 yards, Relative Bearing has decreased to 29°. The Elevation Dials now show less than 1°, Target Course is still 270°, and the Rate of Climb Dial still reads zero.

These dial readings show that the Target is flying low at a constant height and that it will pass ahead of Own Ship if both Ship and Target remain on their present courses.



A SOLUTION IS REACHED

At the time that the Computer is put into Automatic Operation, the Range Finder Signal is white, indicating that the Range Operator has the Target in focus. The Generated and Observed Range Dials turn together as the Generated Changes of Range from the Computer alter the Range Finder focus.

After a few seconds, the Range Finder Signal turns to black. The Target is now out of focus because the Generated Changes of Range are not correct. The Observed Range Dials turn faster than the Generated Range Dials and the indexes are no longer matched as the Range Operator turns his Range Knob to bring the Target into focus.

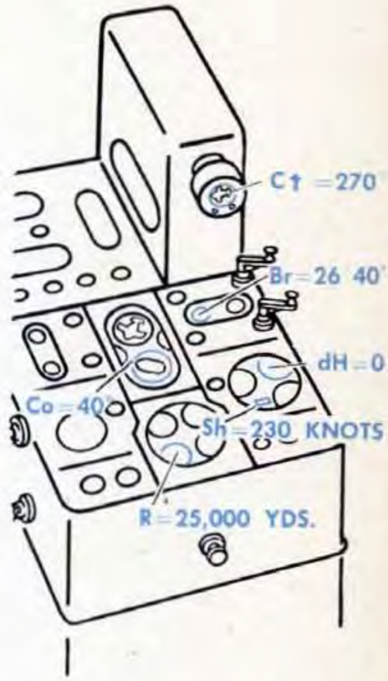
The Range Finder Signal turns to white again, and the dials jump to match at their indexes. The dials turn together as linear and rate corrections to Range are set into the Computer.

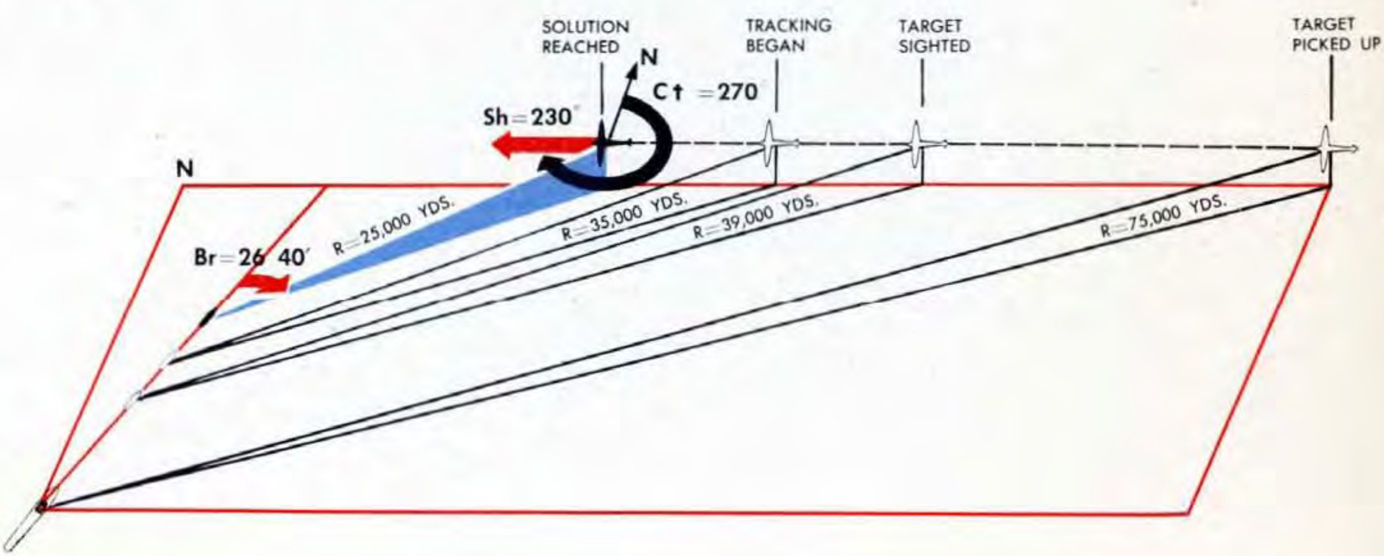
The Range Finder Signal now remains white. The Pointer's and Trainer's Signals remain red. All three operators in the Director are now on Target and the Generated Changes of Range, Elevation, and Bearing are keeping the sights on Target, and the Range Finder in focus. A solution has been reached, and the Computer is transmitting correct orders to the guns. Firing can begin as soon as the Target is within shooting Range.

At the time that the solution is reached, the Range Dials show that the Range has closed to 25,000 yards.

The Relative Target Bearing Dials, which showed 29° at the beginning of tracking, now show 26° 40′.

The Rate Corrections put in by the Trainer and Range Operator have been used by the Computer to correct the estimated value of Target Speed. The Target Speed Counter now reads 230 knots.





The PROBLEM PROGRESSES

The Range Finder Signal remains white and the Pointer's and Trainer's Signals remain red for several minutes after the solution is reached, indicating that the Target is continuing in a straight line at a constant speed.

When the Range Dials read 14,000 yards, the Relative Target Bearing Dials show 20° and Elevation is 2 degrees.

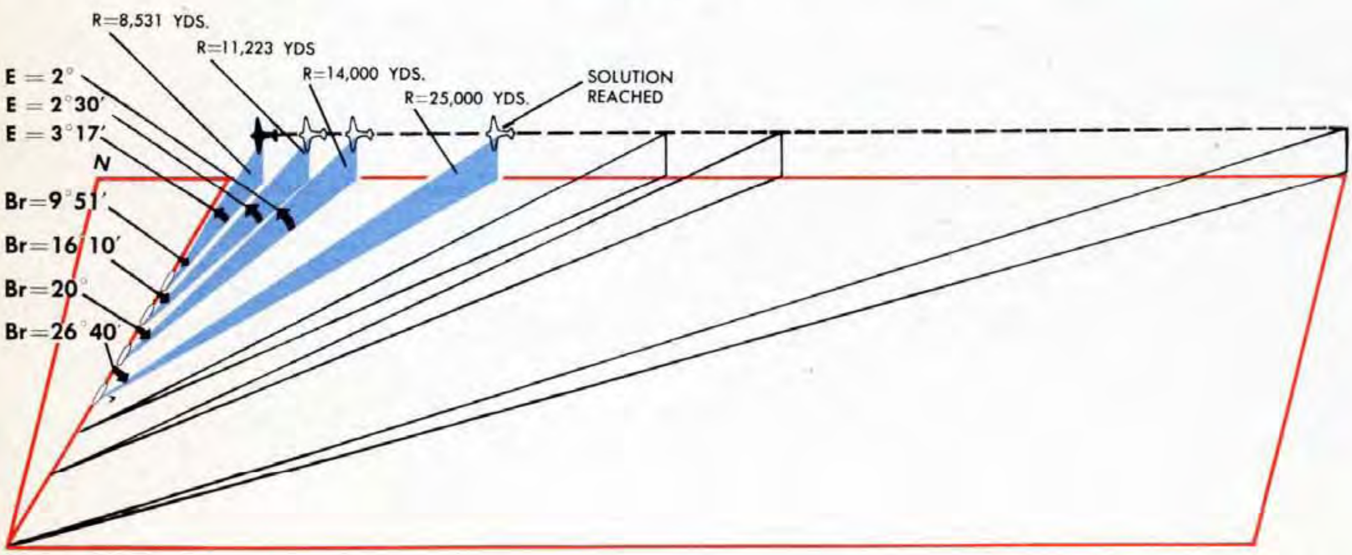
Twenty seconds later the dials are read again to check that the problem is progressing smoothly. At this reading, Range has decreased to 11,223 yards, Relative Target Bearing has decreased to 16° 10′, while Target Elevation has increased to 2° 30′.

The order "*Commence firing*" is given.

The Target is still approaching Own Ship and will cross in front of Own Ship if Target Course does not change. The dial on the Target Course Indicator is at present fairly steady at 220 degrees. The Target Speed Counter shows the Target to be flying at a steady speed of 230 knots.

The Range Finder Signal still remains white and the Pointer's and Trainer's Signals still remain red as the Target approaches, showing that the values generated by the Computer are keeping the Range Finder focused and the sights on the Target. Twenty seconds after the last dial reading, the dials show these new values:

> Range is down to 8 531 yards and Relative Target Bearing is only 9° 51′; Elevation continues to increase slowly and is now 3° 17′.



FIRING CEASES

When Range reaches 6038 yards, an order is received to "*Cease firing.*" This is the usual order given when a Target is brought down.The Computer is ordered back to the original *Standby during Search,* indicating that further action is expected.

The moment that the "*Cease firing*" order is received in the Plotting Room, the dials show that the following changes have taken place:

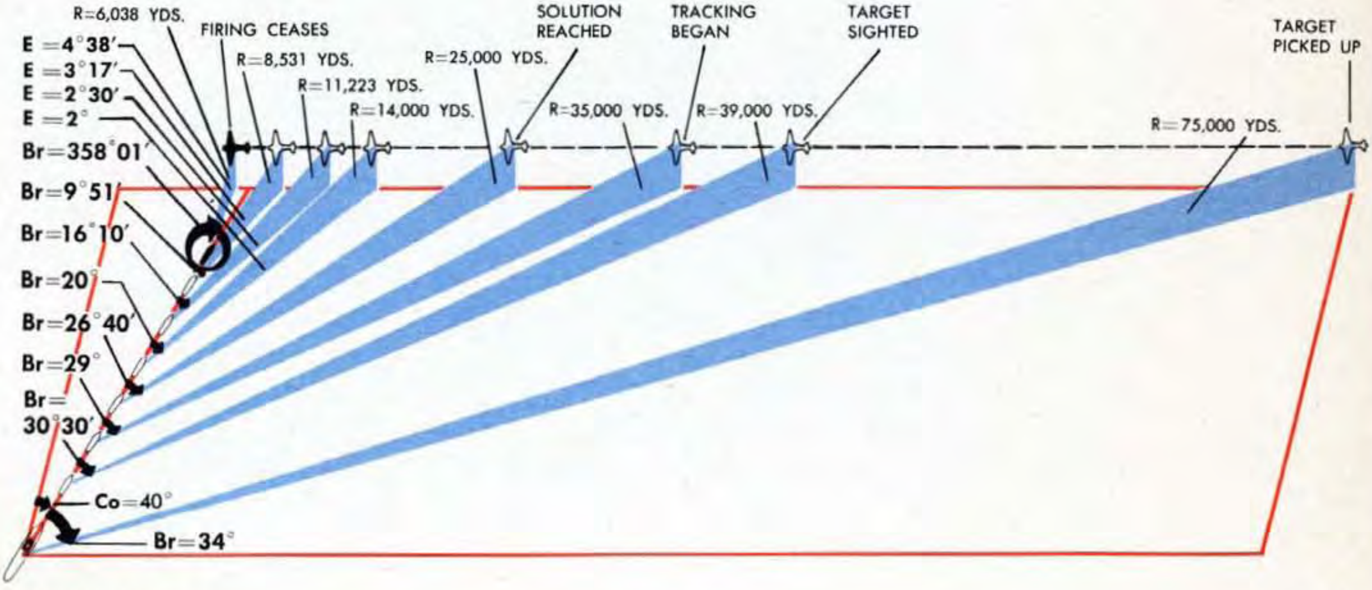
Range has decreased to 6038 yards.

The Target has now crossed in front of Own Ship, causing Relative Target Bearing to move to 358° 01′.

Target Elevation which has been increasing continuously, is now 4° 38′.

A SUMMARY OF THE PROBLEM

Here is a summary of the sample problem as it has been visualized from the Computer Dials:



OPERATING CAUTIONS

To avoid faulty operation of the Computer Mark 1, caution should be used in operating the instrument. Instructions are given here for avoiding some of the most usual sources of damage and faulty operation.

Use of the Time Crank

The Time Crank should never be turned counterclockwise in the OUT position. Although friction drive A-161 is adjusted to slip when the Time line is turned counterclockwise, this friction may be too tight and damage to the Time Motor Regulator may result if the Time line is turned backwards. In the IN position the Time Crank is connected to the Seconds Dial only and may be turned safely in either direction.

Elevation Limit Stops

Various units may slip out of adjustment if the Director Elevation Receiver drives at full speed against the end of the *Eb* limit stop, L-11, or the *E* limit stop, L-12.

Operating instructions are designed to avoid hitting L-11, which may cause clamp A-50 to slip in instruments having serial numbers 1 to 290. In changing from *Standby during Search* to *Standby for An Air or Surface Target,* make sure that the Director Pointer's sights are not at either limit of travel, because the operating limits of *Eb* in the Computer are narrower than in the Director. Then, when the *Eb* transmission circuit is completed, the servo motors will not drive into L-11.

One possible result of hitting the end of L-12 is slippage at assembly clamps A-56 and A-59 in instruments having serial numbers 1 to 290. Such slippage usually occurs when the Director Pointer's sights are slewed beyond the limits of the Computer, or while the Synch *E* Handcrank is being returned from the OUT position to the normal operating position at IN. Slippage due to the latter cause may be avoided by synchronizing as follows:

1. See that the correct value of Level is being received.
2. Put the Synch *E* Handcrank in the CENTER position. Wait until the *Eb* Receiver has synchronized on the signal.
3. Put the Synch *E* Handcrank IN and match the Synch *E* Dials.

Preventing faulty synchronization of Receivers

Due to the heart-shaped relief cams, synchro-receiver units will run toward synchronization in the direction of shorter travel. Under certain conditions, instead of driving to the desired synchronization point, certain receiver units may drive into the end of a limit stop in the opposite direction.

These units are:

The Range Spot Receiver (4000 yards per revolution)
The Elevation Spot Receiver (360 mils per revolution)
The Deflection Spot Receiver (360 mils per revolution)
The Ship Speed Receiver (40 knots per revolution, usually)
The Director Elevation Receiver (180° per revolution)

For an example of a condition under which a unit may drive into the end of a limit stop, consider the Elevation Spot Receiver. The limit stop travel is ± 180 mils, totaling 360 mils. This value, 360 mils, is equal to the value per revolution of the synchro motor. If the instrument setting were UP 150 mils and the transmitted value were DOWN 150 mils when the circuit was energized to receive the signal, the receiver unit would run into the UP 180 mils limit instead of driving back through zero to the desired DOWN 150 mils position.

The Ship Speed and Range Spot Receivers may synchronize a full revolution out. On most installations the *So* limit is 0 to 45 knots and the *So* Synchro has a value of 40 knots per revolution. When the Pitometer Log is on 0 knots, the *So* line in the instrument may therefore drive either to 0 or to 40 knots. In the same way, on modifications of the Computer Mark 1 having the IN 12,000-yard limit, when the Range Spot Transmitter is on 0, the Range Spot Receiver may synchronize on 0, IN 4000, IN 8000, or IN 12,000.

To prevent both faulty synchronization and running into limit stops, the units should be set at the approximate transmitted values, or held at zero position until after the transmission circuits have been completely energized.

Setting I.V.

The *I.V.* correction is actually three corrections: a powder temperature correction based on average magazine temperature, an erosion correction based on average erosion, and an air density correction based on air temperature and barometric pressure.

The standard *I.V.* value of 2550 f.s. for which zero correction is put into the Computer Mark 1 for 5"/38 cal. guns, is taken as an average *I.V.* for a rifle of average age and for average atmospheric conditions. It has no relationship to the standard *I.V.* of the particular ammunition being used. The *I.V.* setting, however, must allow for the standard *I.V.* of the projectile. For example, suppose the ammunition has a standard *I.V.* of 2600 f.s. If powder temperature and barometric pressure are such as to necessitate a +10 correction, and erosion necessitates a −20 correction, the *I.V.* setting will be 2600 + 10 − 20 = 2590. The Computer dial (or dials on Serial Nos. 811 up) must be set at 2590, NOT at 2550 + 10 − 20 = 2540.

The Range Rate/Diving Speed Handcrank

The handcrank labeled *Range Rate/Diving Speed* should be set at AUTO during normal operation of the Computer. It is used at HAND only during certain DIVE ATTACK problems. Since this handcrank is often set at HAND during testing, the operator should check to make sure that it is at AUTO during normal operation.

The Rrr Knob

The Range Rate Ratio Knob engages at only one position. To make sure that the knob is engaged, turn the knob in a decreasing direction to Ratio 1, and check that the limit of travel is reached.

Shifting from Semi-automatic Operation to Automatic or Local Operation

It is sometimes desirable to shift to Automatic Operation after reaching a solution of an air problem in Semi-automatic Operation. Since there is no definite matching point between Observed and Generated values of Bearing and Elevation in SEMI-AUTO, as there is in AUTO and LOCAL, the solution can easily be upset by shifting to AUTO without special care. If the Computer operator shifts to AUTO while the Pointer and Trainer have their signal keys closed, the *jE* and *jBr* Motors will drive the inner Elevation and Bearing Dials up to as much as 20° travel and will put in corresponding amounts of rate corrections. The solution will be considerably upset. If the Generated Elevation and Generated Bearing Cranks are left in the IN position when control is shifted to AUTO, the solution will be even more upset.

If a solution has been reached or even partially reached in SEMI-AUTO and it is desired to shift to AUTO, the following procedure should be followed:

1. Set the Generated Elevation and Generated Bearing Cranks in the OUT position.
2. Shift the Target Speed Handcrank to HAND.
3. Turn the Control Switch to AUTO.
4. Wait until the *jE* and *jBr* Motors drive the inner dials to synchronization; then shift the Target Speed Handcrank back to AUTO to resume Rate Control.

If it is desired to shift to LOCAL while tracking a surface target in SEMI-AUTO, synchronize Generated Bearing with Observed Bearing before making the shift to LOCAL.

Synchronize Generated Bearing with Observed Bearing as follows:

1. Shift to AUTO until the dials are synchronized.
2. Shift back through SEMI-AUTO to LOCAL.

If this is not done, Observed Bearing will run off the correct value by some amount up to 20 degrees.

QUICK REFERENCE INDEX

More detailed breakdown on next two pages.

This page is hot linked. Click the page/subject you want. The file is also searchable. Enter the phrase you want in search block. If that does not work, try a different phrase OCR isn't perfect.

If link does not work, the page you want is in a different file. Return to original page to download.

Part 3

DETAILED DESCRIPTION

The solution of the fire control problem can be divided among eight separate groups of mechanisms in the Computer Mark 1. Each of these groups forms a network which solves a portion of the problem. All eight networks in the Computer operate simultaneously, and a solution of the fire control problem is continuously transmitted to the guns all the time the Computer is in operation.

In this Detailed Description the first eight chapters describe the eight computing networks in the order in which the solution from each network builds toward the solution of the whole problem. Each computing mechanism is described in the order in which it solves its portion of the problem, without regard to its physical position in the Computer. The last two chapters describe the Star Shell Computer network and the Selector Drive.

An understanding of each network and of the interrelation between the various networks will give a complete picture of the method by which the Computer Mark 1 solves the fire control problem.

The Detailed Description is divided into the following chapters:

DETAILED KNOWLEDGE OF THE COMPUTER

The Detailed Description of the Computer Mark 1 may seem highly theoretical, but most of it is very useful information for anyone who is to operate the Computer, and indispensable to anyone who is to test, set, or maintain the Computer.

Why operators should read the detailed description

The operator who is familiar with what is going on under the covers of the Computer Mark 1 will have confidence in the instrument and in his own handling of it. He will be able to visualize the fire control problem and see more quickly what the Computer needs to reach a solution in any given situation. He will use the types of operation best suited to each problem and will not be tempted to avoid certain types because they may appear more complex.

An operator with a knowledge of the Detailed Description will understand and remember operating instructions more easily, he will be able to switch from one type of operation to another with greater speed and accuracy, and he will be equipped with the knowledge and confidence he needs to meet new situations and emergencies as they arise. For example: An operator may discover that a handcrank which should be in the AUTO position is in the HAND position. The man who is familiar with the Computer will know whether or not changing this handle to AUTO will introduce violent changes in the Computer outputs with consequent danger to either the Gun Crew or the Director Crew.

An informed operator will be much better able to prevent casualties. The operator who is merely following memorized instructions will be apt to overlook signs of trouble and to continue operation of the instrument until a casualty occurs.

Operators with detailed knowledge of the Computer will also be better able to detect faulty operation by the Director Crew and thus create a basis for better Director-Computer coordination.

HAS MANY PRACTICAL USES

Operation by a well-informed crew can save needless wear and tear on the Computer mechanisms. For instance, an understanding of the proper use of the Selector Drive will eliminate much needless wear in the Trunnion Tilt Section of the Computer.

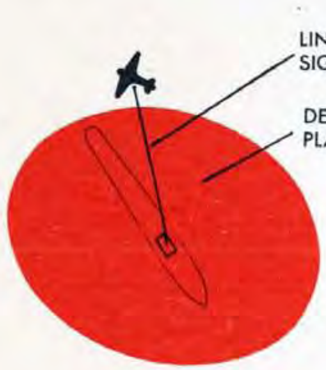
Another advantage of knowing the inside as well as the outside of the Computer is the background it provides for evaluating the word-of-mouth suggestions picked up from the fire control crews of other ships.

Why maintenance personnel must read the detailed description

The Detailed Description is required information for anyone who is going to test, set, or maintain the Computer Mark 1. The relationship of the mechanisms within each network, and the relationship of the networks to each other are explained here. The consequence of neglecting an upset clamp, a bent shaft, or a stuck gear cannot be appreciated fully without a thorough knowledge of the way in which the Computer mechanisms work together.

A man who has studied the Detailed Description will also realize the importance of finding the exact location of trouble in the Computer. He will know the interconnections between the networks and be able to locate trouble without difficulty.

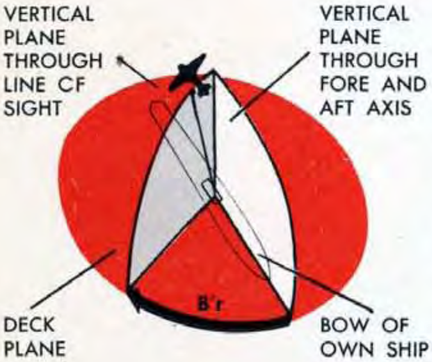
DECK TILT



The Deck Tilt Group computes a stabilizing quantity called Deck Tilt Correction, $jB'r$.

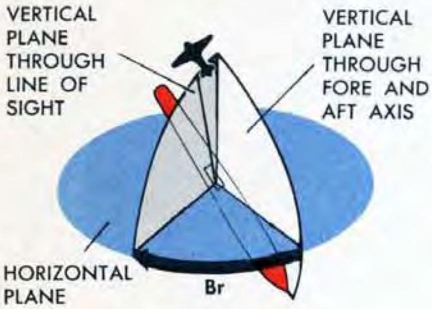
One of the input quantities which the Computer Mark 1 needs is a *horizontal* measure of the Target's bearing relative to the fore and aft axis of Own Ship. This horizontal measure of the Target's relative bearing is called Relative Target Bearing, Br. Br is the angle, *in the horizontal plane,* between the vertical plane through the fore and aft axis of Own Ship and the vertical plane through the Line of Sight, measured clockwise from the bow. Br is needed for computing Relative Motion Rates and Rate Control Corrections.

Br cannot be measured directly by the Gun Director Mark 37.



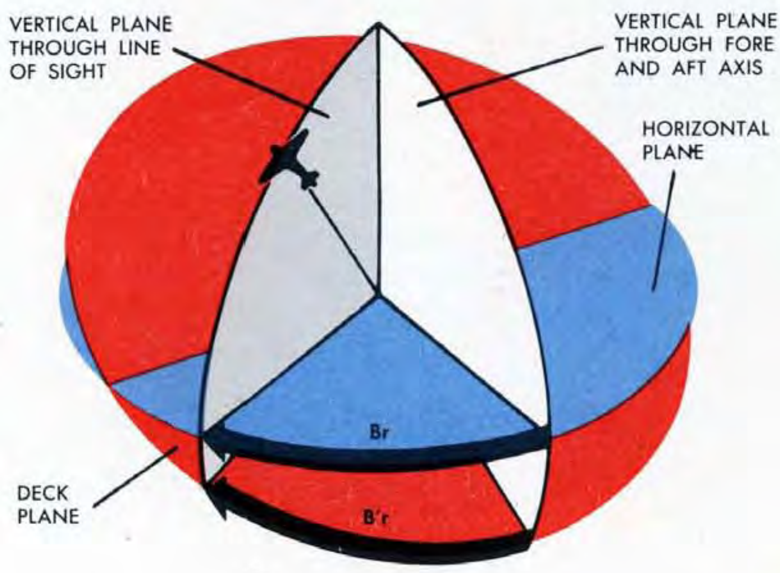
Since the Director is mounted on a roller path in the deck plane, the whole Director trains in the *deck* plane, and tilts with the deck as Own Ship rolls and pitches. When the sights are on the Target, the Director measures the Target's bearing relative to the fore and aft axis of Own Ship *in the deck plane*. This measure of the Target's relative bearing in the deck plane is called Director Train, $B'r$. $B'r$ is the angle between a vertical plane through the fore and aft axis of Own Ship and a vertical plane through the Line of Sight, measured *in the deck plane,* clockwise from the bow of Own Ship.

In order to convert $B'r$ to Br, the Computer Mark 1 must continuously compute the amount by which $B'r$ differs from Br. This computed difference between $B'r$ and Br is called Deck Tilt Correction, $jB'r$.



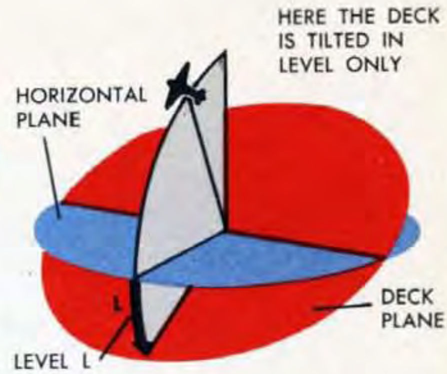
Br is obtained by continuously adding the computed Deck Tilt Correction, $jB'r$, to the measured value of Director Train, $B'r$.

$$Br = B'r + jB'r$$



NOTE:
Strictly speaking, the term "deck plane" does not mean a plane through the deck, but a plane through the Director sights parallel to the Director roller path.

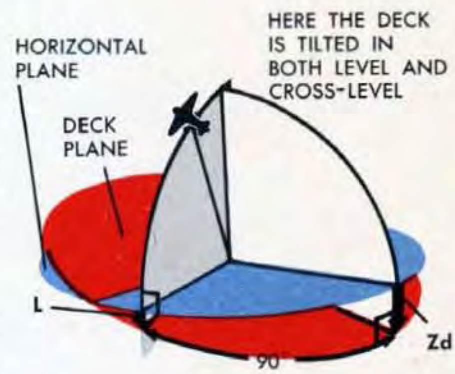
THE INPUTS to the deck tilt group



The quantities used in computing Deck Tilt Correction, *jB′r,* are Director Train, *B′r,* Level, *L,* and Cross-level, *Zd.*

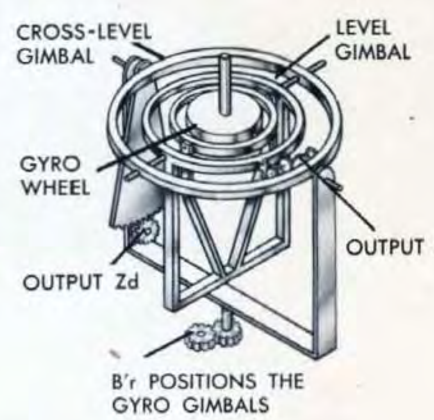
Level, *L,* and Cross-level, *Zd,* are measures of deck inclination.

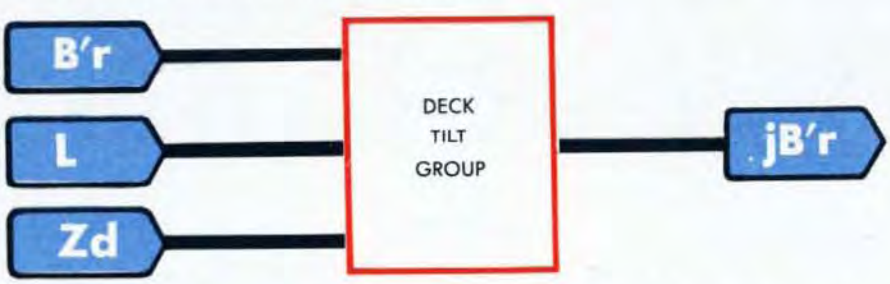
Level, *L,* is the angle between the horizontal plane and the tilted deck plane measured in the vertical plane through the Line of Sight. The correction for *L* is positive when the deck toward the Target tilts down.



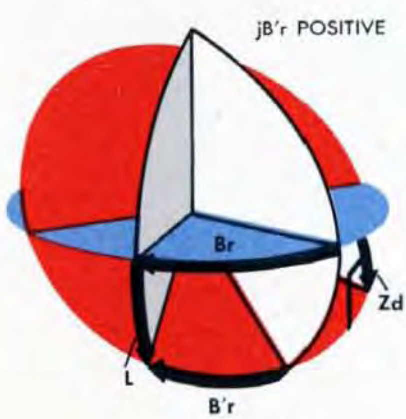
Cross-level, *Zd,* is the angle between the horizontal and the tilted deck measured in a plane at right angles to the deck plane, and at right angles to the vertical plane through the Line of Sight. The correction for *Zd* is positive if, when facing the Target, the deck to the left tilts down.

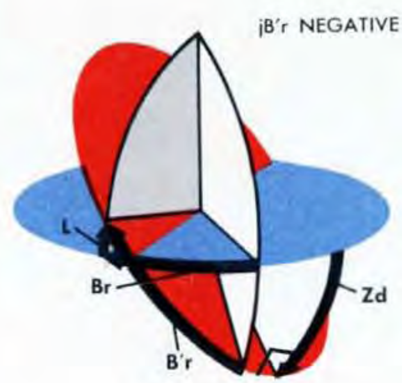
L and *Zd* are continuously measured by the Stable Element. The Stable Element contains a gyro which, within its limits of operation, always remains in the horizontal plane regardless of the inclination of the deck. The Computer transmits the value of Director Train, *B′r,* by a shaft line to the Stable Element. *B′r* positions the gyro gimbals so that measurements of deck inclination are made in relation to the Line of Sight. The measurements are the values of Level and Cross-level, and are transmitted by shafts to the Computer.



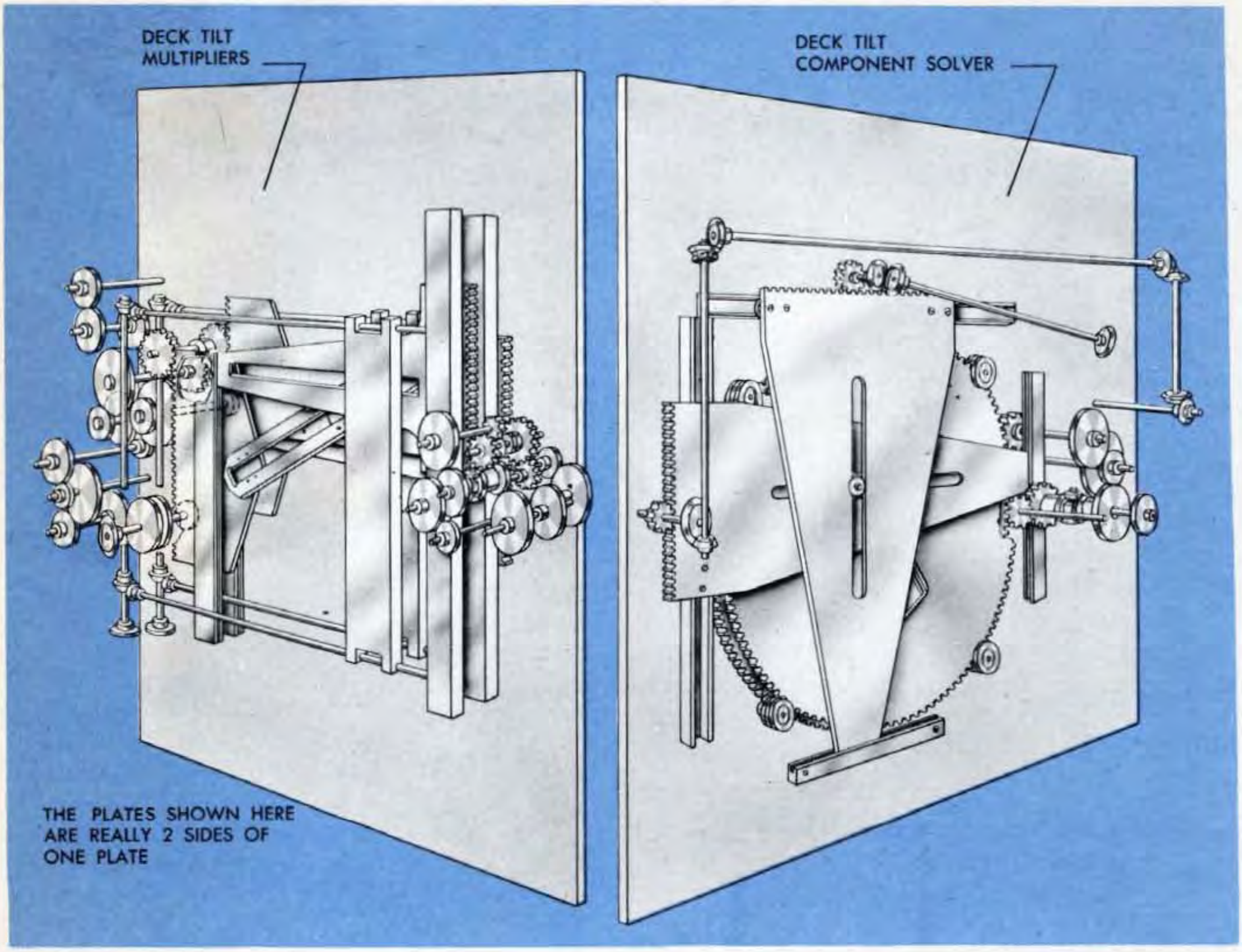


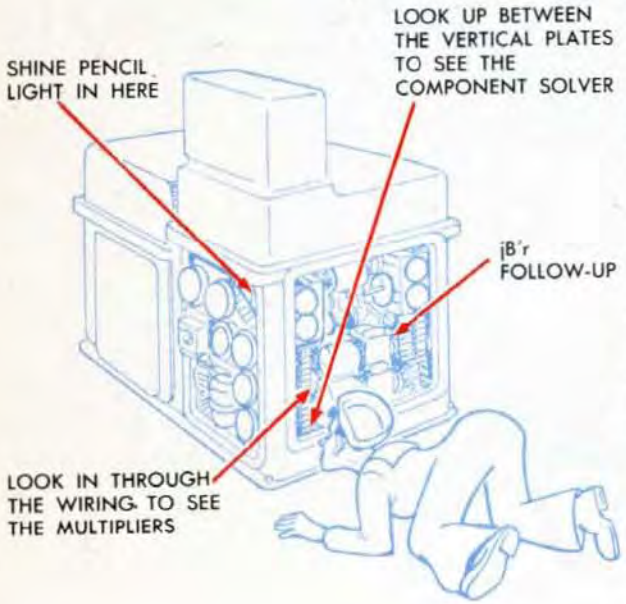
Deck Tilt Correction, *jB′r,* may be either positive or negative. When *Br* is larger than *B′r, jB′r* is positive. When *Br* is smaller than *B′r, jB′r* is negative.





The DECK TILT MECHANISM and the equation it solves





The Deck Tilt Mechanism consists of a component solver, two screw-type multipliers, a compensated follow-up control, and several differentials. The Deck Tilt Component Solver and Multipliers are mounted on a plate in the lower rear of the Computer Mark 1, between the Parallax and the Trunnion Tilt mechanisms.

The true equation for Deck Tilt Correction, $jB'r$, contains terms which would require a long network of mechanisms for their solution. To obtain a sufficiently correct value of $jB'r$ using only a few mechanisms, the true equation has been modified for use in the Computer Mark 1.

Here is the modified equation:

$$jB'r = K[Zd(L - L\cos 2B'r) + K_1 L \cdot L \sin 2B'r]$$

This equation for $jB'r$ looks complicated but it is solved by only a few mechanisms: the component solver, the two multipliers, and the differentials.

The Deck Tilt COMPONENT SOLVER

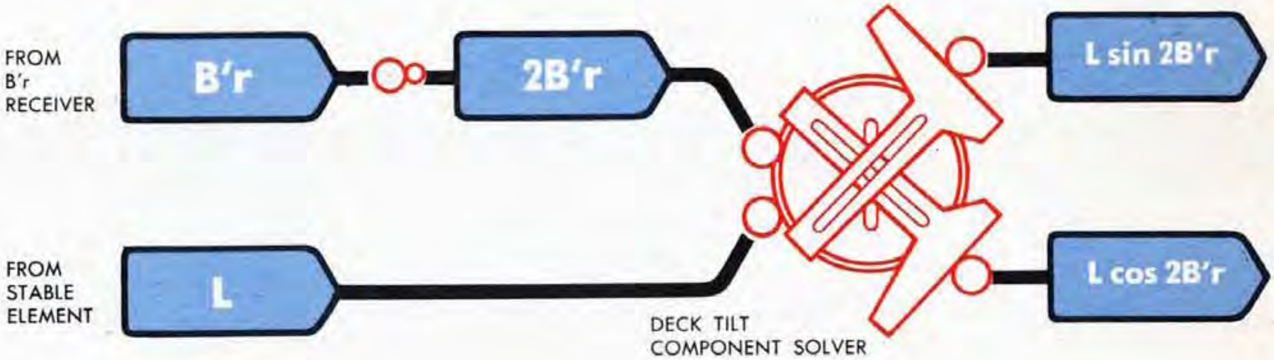
The first step in the solution of the $jB'r$ equation is to compute the quantities $L \sin 2B'r$ and $L \cos 2B'r$. These two quantities are computed in the Deck Tilt Component Solver.

The inputs to the component solver are $2B'r$ and L.

The quantity $2B'r$ is difficult to visualize and does not occur in the true equation for $jB'r$. It is used in the modified equation in approximating the value of certain other terms which would be difficult to compute mechanically.

The value of $2B'r$ positions the vector gear in the Deck Tilt Component Solver. Since $2B'r$ is twice the value of $B'r$, the vector gear makes two complete revolutions while the value of $B'r$ changes from zero to 360 degrees. A cam-type component solver is used here because in this type the vector gear may turn through any number of revolutions.

Level, L, positions the cam. An offset pin is used in the component solver because the values of L are alternately positive and negative. This type of component solver is described in detail in OP 1140.



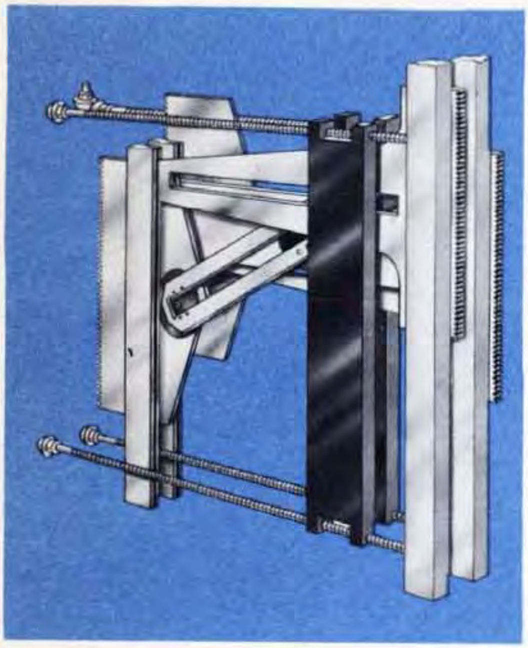
Director Train, $B'r$, from the $B'r$ Receiver is multiplied by 2 in a gear ratio producing $2B'r$. The value of $2B'r$ positions the vector gear. Level, L, from the Stable Element is the cam input.

The two outputs from the component solver are: $L \sin 2B'r$ and $L \cos 2B'r$.

The use of $2B'r$ in the Deck Tilt equation gives the same value of $jB'r$ for given values of L and Zd, whether $B'r$ is 90° or 270 degrees. With given values of L and Zd, the value of $jB'r$ will be the same with a given $B'r$ value as for a $B'r$ value 180° greater or less.

NOTE:
It should be remembered that every component solver has a compensating differential. The function of the compensating differential is explained in OP 1140. For clarity this differential is omitted from the flow schematics in OP 1064.

The Deck Tilt MULTIPLIERS



The remaining quantities in the Deck Tilt equation are solved by two screw-type multipliers, two differentials, and some gearing.

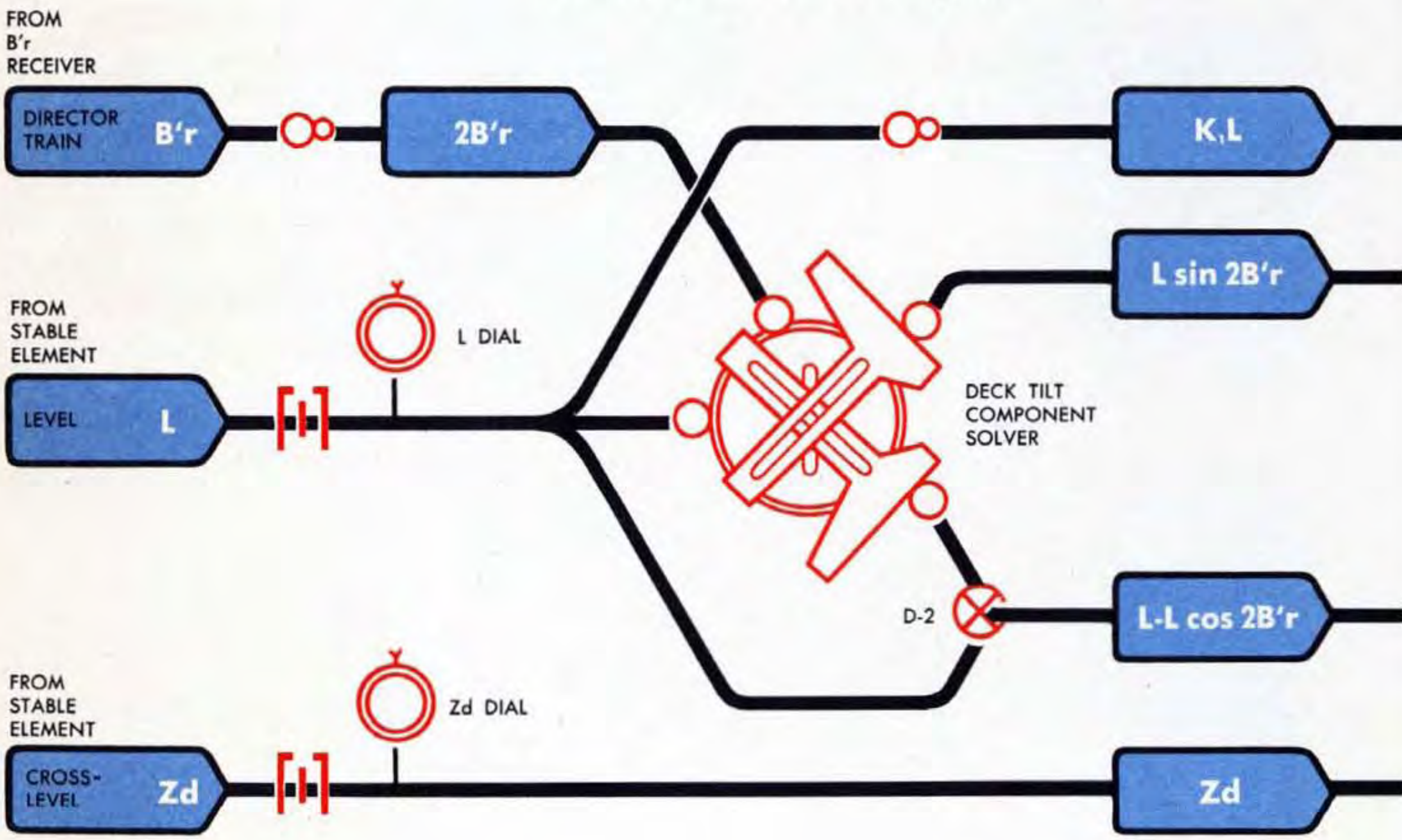
The $L \cos 2B'r$ output of the Deck Tilt Component Solver is subtracted from L at differential D-2. The result, $(L - L \cos 2B'r)$, positions the input rack of one of the multipliers. Zd positions the lead screw. The multiplier output is the first term of the Deck Tilt equation:

$$Zd\ (L - L \cos 2B'r).$$

The $L \sin 2B'r$ output of the component solver positions the input rack of the second multiplier. A gear ratio is used to multiply L by K_1 to obtain K_1L, which positions the lead screw. The output is the second term of the $jB'r$ equation:

$$K_1L \cdot L \sin 2B'r.$$

The inputs to each of the Deck Tilt Multipliers may have either positive or negative values. The fixed pin in each multiplier is therefore located at the center of travel of the inputs.



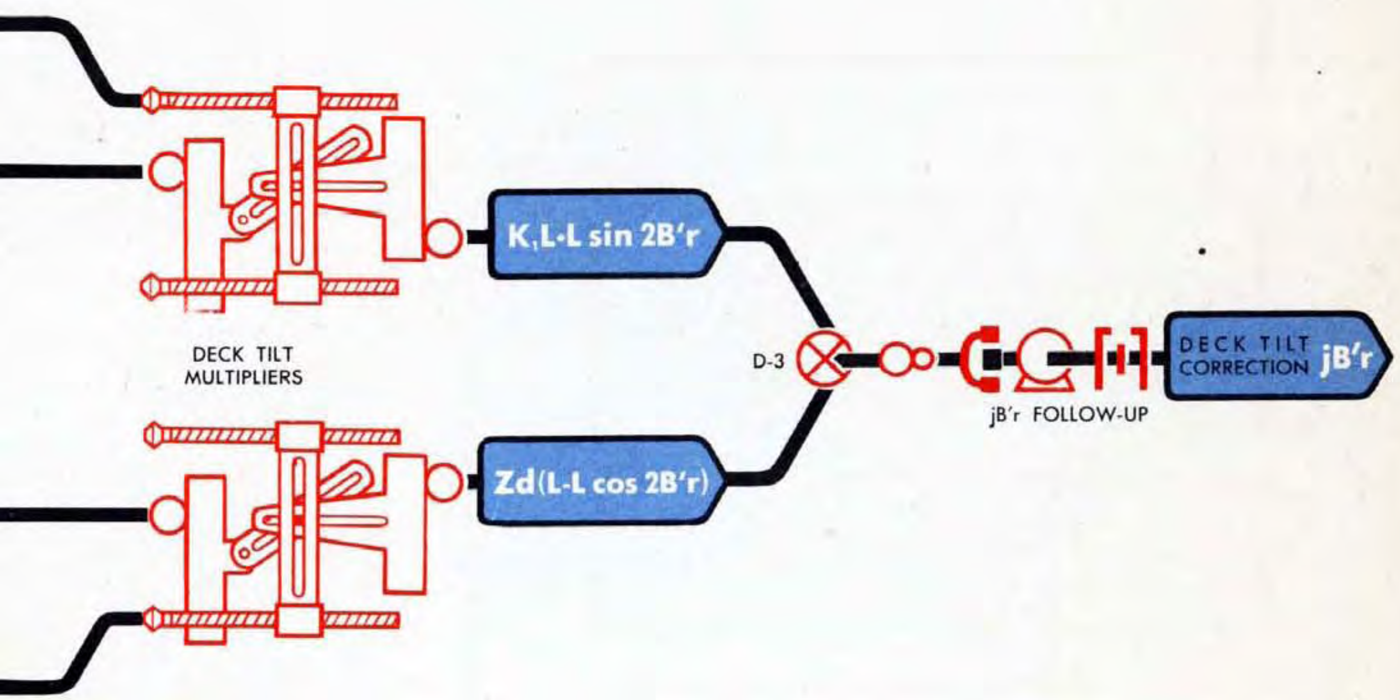
complete the equation

The outputs from the two Deck Tilt Multipliers are added together at differential D-3. The differential output is multiplied in gearing by a constant, K, to form the quantity:

$$K[Zd\,(L - L\cos 2B'r) + K_1 L \cdot L\sin 2B'r] \text{ which is } jB'r$$

A compensated follow-up amplifies the torque on the $jB'r$ line and drives $jB'r$ to the Relative Motion and the Integrator Groups.

Since the $jB'r$ Follow-up is always energized when the Power Switch is ON, the Deck Tilt Correction is continuously available in all types of operation.



How jB′r is used

Deck Tilt Correction, $jB'r$, is used to correct two different quantities:

1 Director Train, $B'r$, which is received in the Computer from the Director.

2 Generated Changes of Relative Target Bearing, $\triangle cBr$, which are transmitted from the Computer to the Director.

The quantity, $B'r$, received in the Computer is an angle in the deck plane. The Deck Tilt Correction, $jB'r$, is added to $B'r$ to obtain Relative Target Bearing, Br, the corresponding angle in the horizontal plane.

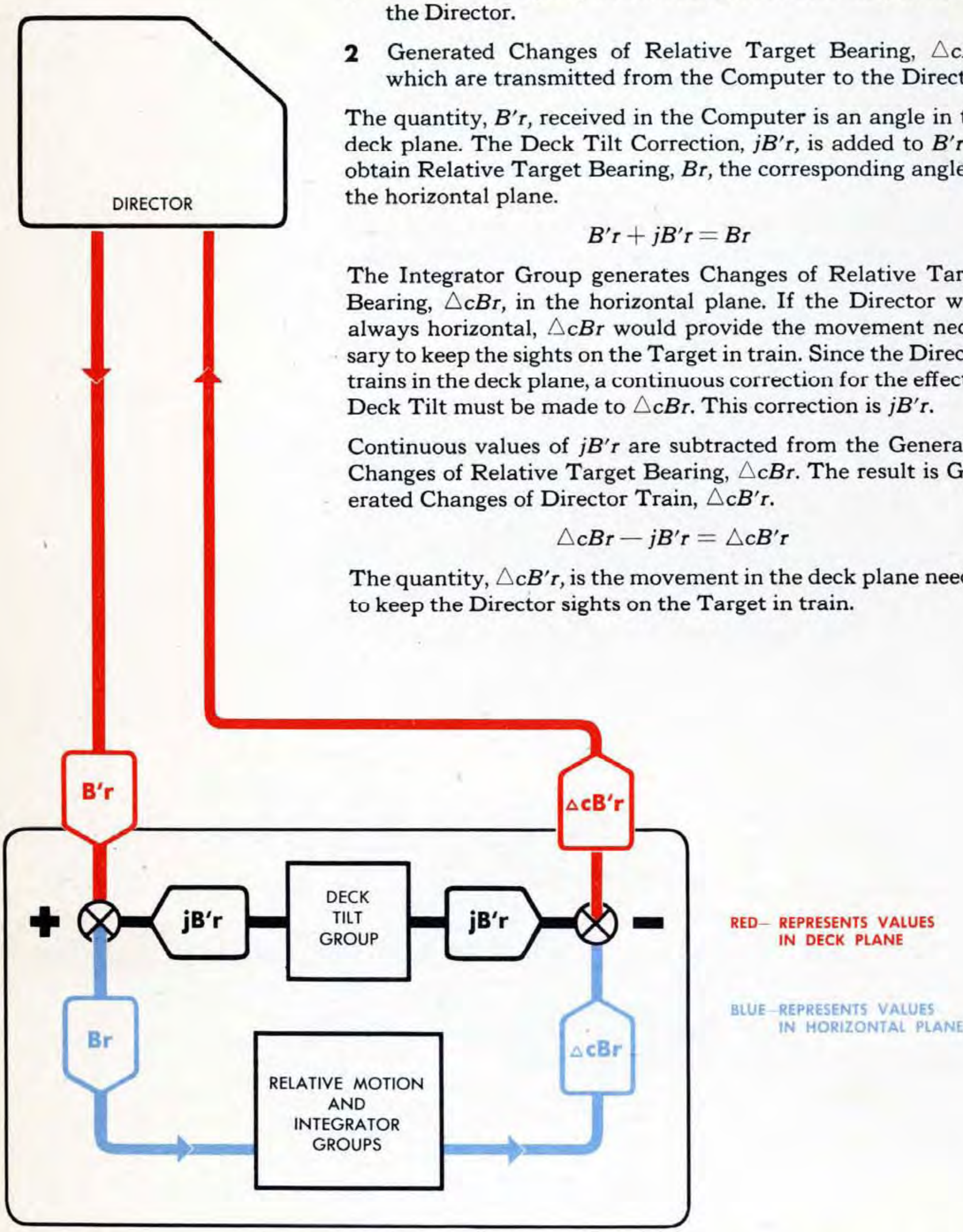
$$B'r + jB'r = Br$$

The Integrator Group generates Changes of Relative Target Bearing, $\triangle cBr$, in the horizontal plane. If the Director were always horizontal, $\triangle cBr$ would provide the movement necessary to keep the sights on the Target in train. Since the Director trains in the deck plane, a continuous correction for the effect of Deck Tilt must be made to $\triangle cBr$. This correction is $jB'r$.

Continuous values of $jB'r$ are subtracted from the Generated Changes of Relative Target Bearing, $\triangle cBr$. The result is Generated Changes of Director Train, $\triangle cB'r$.

$$\triangle cBr - jB'r = \triangle cB'r$$

The quantity, $\triangle cB'r$, is the movement in the deck plane needed to keep the Director sights on the Target in train.



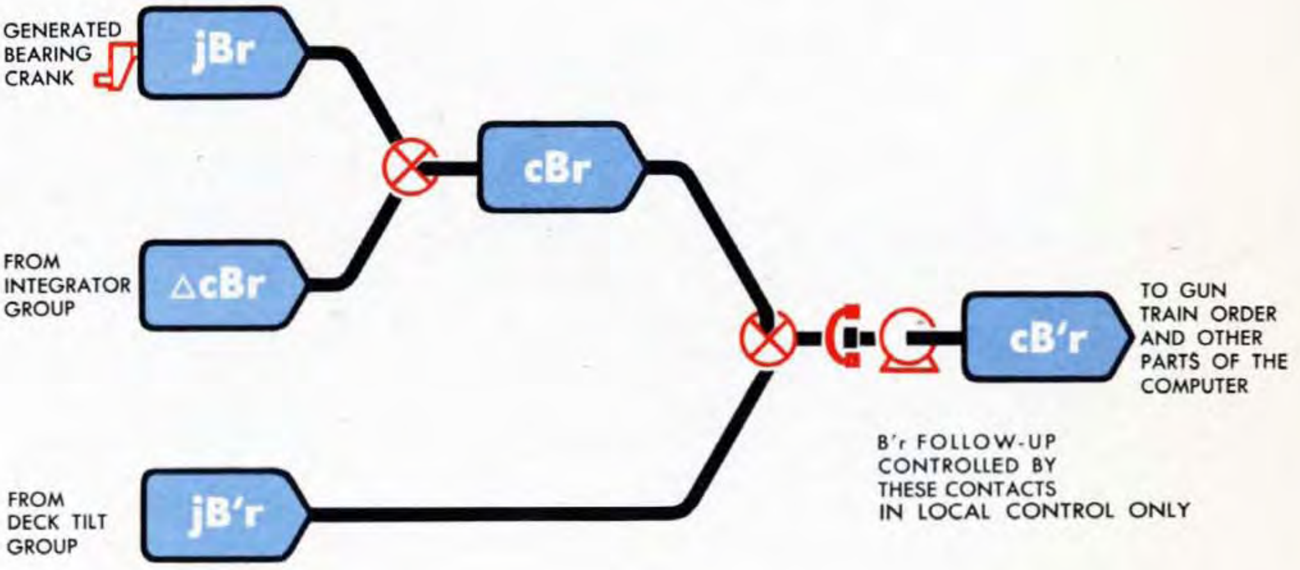
jB′r in Local Control

When, for any reason, no *B′r* signal is coming in from the Director, the Computer Mark 1 can compute a substitute value of Director Train, *B′r*. This substitute is Generated Director Train, *cB′r*.

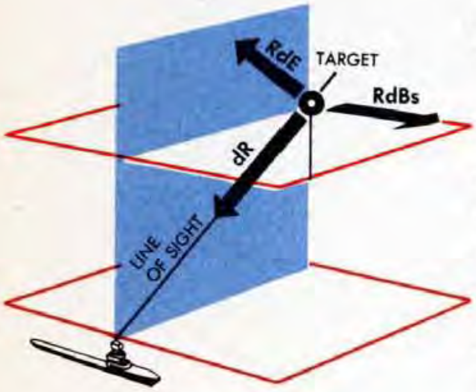
Generated Director Train, *cB′r*, consists of a manual setting of Relative Target Bearing, *jBr*, plus the Generated Changes of Bearing, $\triangle cBr$, from the Integrator Group, plus the Deck Tilt Correction, *jB′r*.

The angle, $jBr + \triangle cBr$, is the Generated Relative Bearing in the horizontal plane. The addition of Deck Tilt Correction, *jB′r*, produces an accurate value of *cB′r* in the deck plane.

The quantity *cB′r* is used to control the *B′r* Follow-ups in Local Control only. In Automatic and Semi-automatic Control, these follow-ups are positioned by the *B′r* Receiver. The operation of the *B′r* Follow-ups is described in detail in the chapter on Rate Control, pages 258-259.



RELATIVE MOTION



Relative Motion is the change of position of the Target as viewed from Own Ship. This change of position, or relative motion, may be the result of Target Motion only, Ship Motion only, or a combination of both Ship and Target Motion.

The job of the Relative Motion Group in the Tracking Section of the Computer Mark 1 is to compute the three Relative Motion Rates: Direct Range Rate, *dR,* Elevation Rate, *RdE,* and Deflection Rate, *RdBs.*

The RATES of Relative Motion are the speeds with which the Target is changing position in relation to Own Ship. For an air target, a Relative Motion Rate is computed in each of three directions in relation to the Line of Sight to the Target:

1. Directly along the Line of Sight
2. At right angles to the Line of Sight in the horizontal plane
3. At right angles to the Line of Sight in the vertical plane through the Line of Sight.

These three directions are chosen because the resulting rates can best be used for computing changes of Range, Elevation, and Bearing.

The Relative Motion Rate directly along the Line of Sight is Direct Range Rate, *dR*. Range Rate, *dR,* is the rate at which the Range is changing, and is needed by the Prediction Section to compute the change in Range that takes place during the time the projectile is in flight.

The Relative Motion Rate at right angles to the Line of Sight in the vertical plane is Elevation Rate, *RdE*. Elevation Rate, *RdE,* is the linear rate at which the Elevation of the Target is changing, as viewed from Own Ship. It is needed by the Prediction Section to compute the change in Elevation that takes place during the time the projectile is in flight.

The Relative Motion Rate at right angles to the Line of Sight in the horizontal plane is Deflection Rate, *RdBs*. The Deflection Rate is the linear rate at which Relative Target Bearing is changing. It is needed by the Prediction Section to compute the change in Bearing that takes place during the time the projectile is in flight.

The Height, *H,* of the Target is also computed by the Relative Motion Group.

The INPUTS to the Relative Motion Group

To compute the three Relative Motion Rates and Height, the Relative Motion Group needs three groups of inputs:

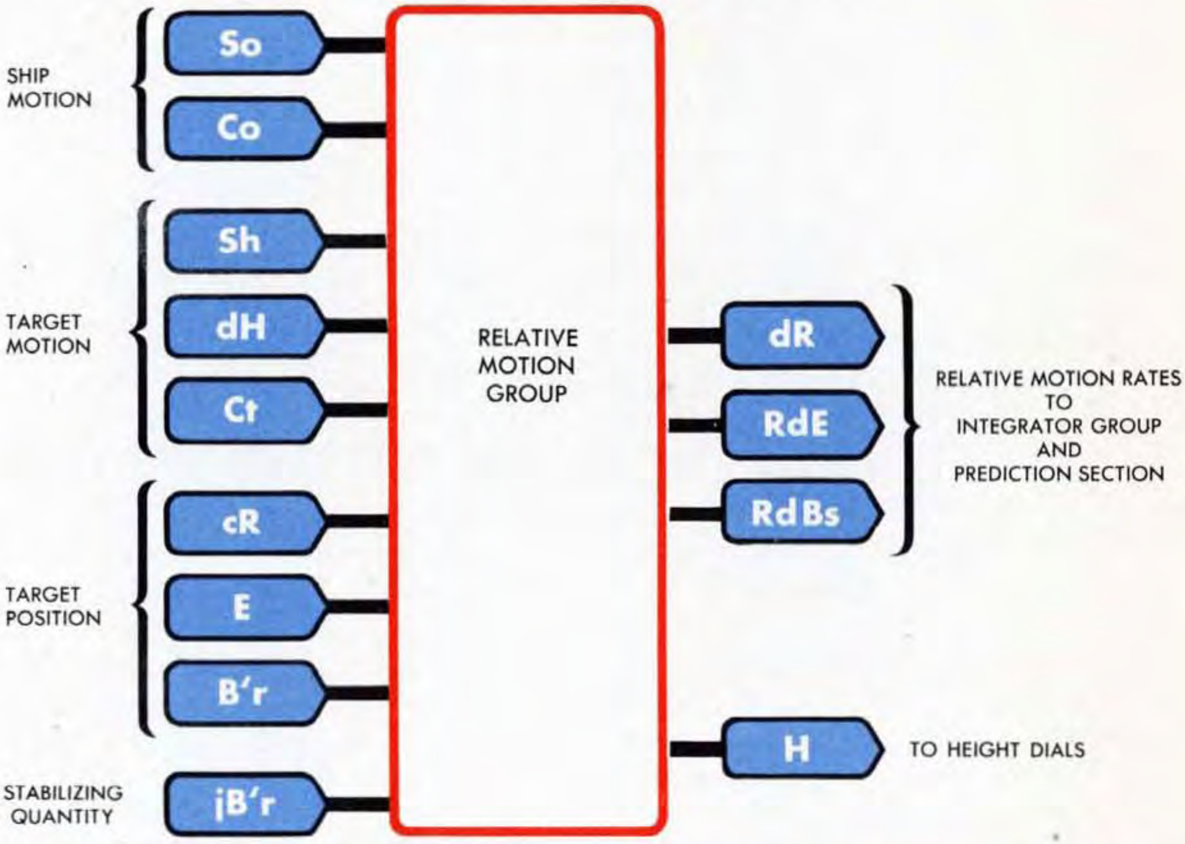
1 Ship Motion inputs
2 Target Motion inputs
3 Target Position inputs.

The Ship Motion inputs are Ship Speed, *So,* and Ship Course, *Co.*

The Target Motion inputs are Target Horizontal Speed, *Sh,* Target Course, *Ct,* and Rate of Climb, *dH.*

The Target Position inputs are Target Elevation, *E,* Director Train, *B′r,* and Present Range, *cR.*

In addition to these three groups, one stabilizing input is needed. This stabilizing input is Deck Tilt Correction, *jB′r.*



The OUTPUTS of the Relative Motion Group

Relative Motion Rates, *dR, RdE,* and *RdBs,* go to the Prediction Section and also to the Integrator Group in the Tracking Section.

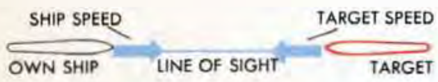
The fourth output, Target Height, *H,* goes only to the Height Dials.

COMPONENTS

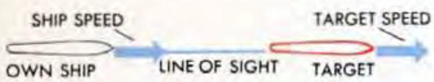
The Rates of Relative Motion depend on the speed and direction of motion of both Ship and Target. To compute these rates, the velocities of Ship and Target must be broken into components in the directions in which the rates are required. The components are necessary because the *direction* in which the Ship or Target is moving in relation to the Line of Sight determines how much of its velocity affects Range, Elevation, or Bearing.

NOTE:
It will be remembered that Target *speed* and Target *direction*, taken together, are called Target Velocity. Velocity is *speed* in a given *direction*.

The need for resolving velocities into their components is most easily shown in computing rates of Relative Motion between Own Ship and a surface target. With a surface target only two rates are needed: Range Rate and Deflection Rate.



RANGE RATE = SUM OF SPEEDS



RANGE RATE = DIFFERENCE BETWEEN SPEEDS

When own ship and a surface target are moving in the same straight line

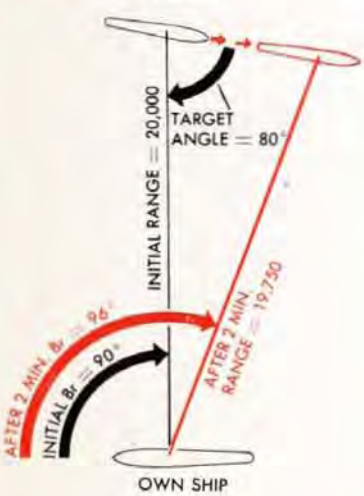
When Own Ship and a surface target are moving in the same straight line, they are moving along the Line of Sight. Their speeds affect Range only. There is no motion at right angles to the Line of Sight; therefore the Deflection Rate is zero. The Range Rate is computed by adding or subtracting the speeds of Ship and Target depending on whether they are moving in opposite directions or in the same direction.

When they are moving in opposite directions, the sum of their speeds is the Range Rate. When they are moving in the same direction, the difference in their speeds is the Range Rate.

When own ship and a surface target are moving on different courses

When Own Ship and a surface target are moving on different courses, their speeds cannot be simply added or subtracted to obtain a Relative Motion Rate. The *direction* of their motion in relation to the Line of Sight must be considered.

Suppose that Own Ship is stationary and the Target is directly abeam of Own Ship with Relative Target Bearing, *Br*, at 90° and Range 20,000 yards. If Target Angle, *A*, is 20° and the Target moves in a straight line at 30 knots for two minutes, the Range will have decreased by about 1900 yards to 18,100 yards, and the Relative Bearing will have increased by approximately 2° to 92°.

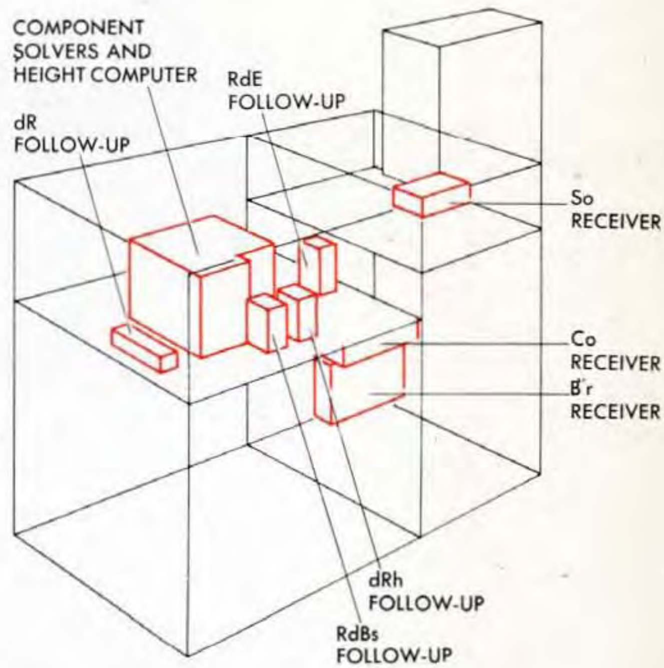


If, however, with the same initial relative positions, Target Angle, *A*, had been 80° and the Target had moved at 30 knots for two minutes, the results would have been quite different. Range would have decreased only 250 yards, to 19,750 yards, while Relative Bearing would have increased approximately 6° to 96°.

These examples demonstrate that usually only a fraction of the actual Target Speed affects Range, and only a fraction affects Bearing. These fractions are called components, and their sizes depend on the speed of the Target and the value of Target Angle, *A*.

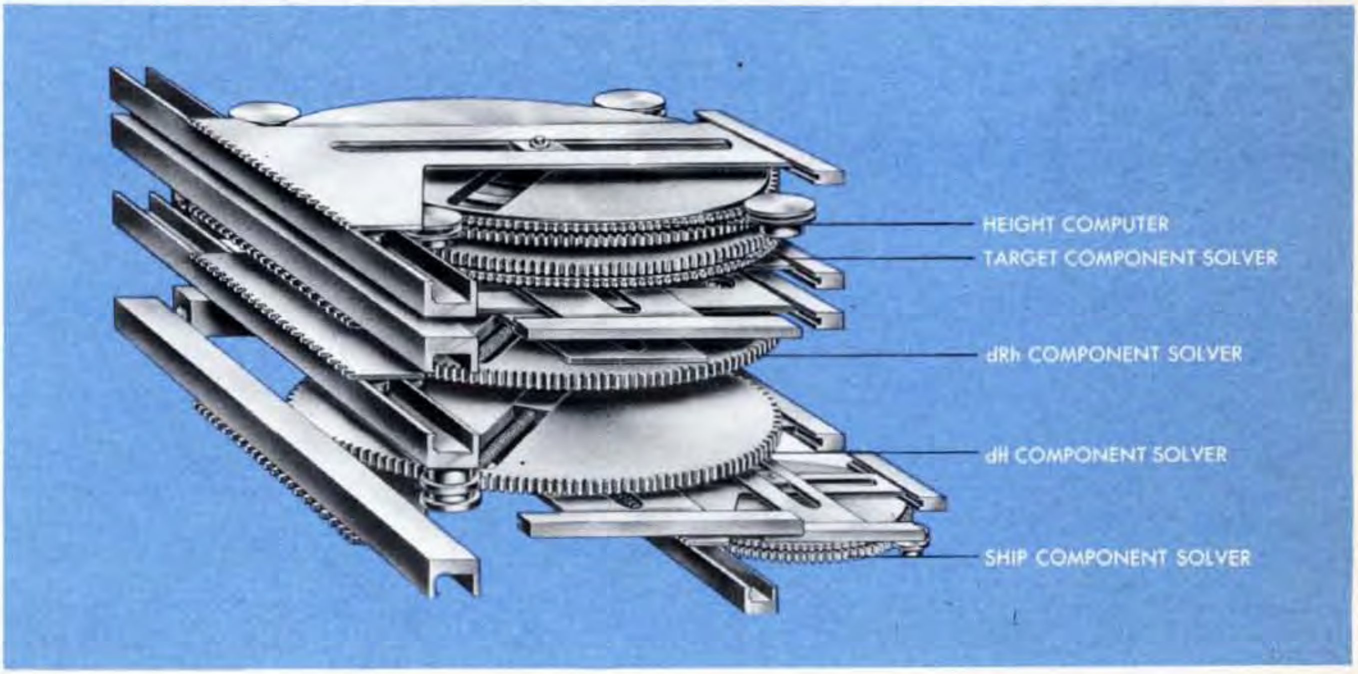
In the same way, the effect of Own Ship Speed on Range and Bearing depends on the value of Ship Speed, *So,* and Relative Target Bearing, *Br*.

The Components of Own Ship Velocity, Target Velocity, and the other velocity vectors needed for air targets are computed in the Relative Motion Group by the Relative Motion Component Solvers.

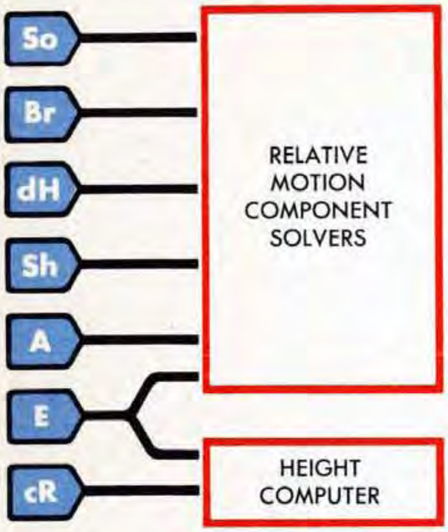


THE MECHANISM in the relative motion group

The Relative Motion Group contains a bank of four component solvers and the Height Computer, the *B'r* and *Co* Double-speed Receivers, the *So* Single-speed Receiver, the follow-ups on the *dR, RdE, RdBs,* and *dRh* lines, and various differentials and dials. The component solvers and all the follow-ups are in the top front section of the Computer. The *Co* Receiver is in the lower front section. The *So* Receiver is in the top rear section, and the *B'r* Receiver is in the lower rear section.

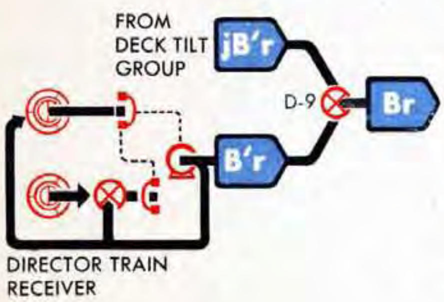


The inputs to the Component Solvers



The Relative Motion Rates are computed in relation to the horizontal plane and to the Line of Sight. Some of the inputs to the Computer are quantities measured from the deck plane or from *North*. These quantities cannot be used directly as inputs to the component solvers, but are used to compute the inputs needed by the component solvers.

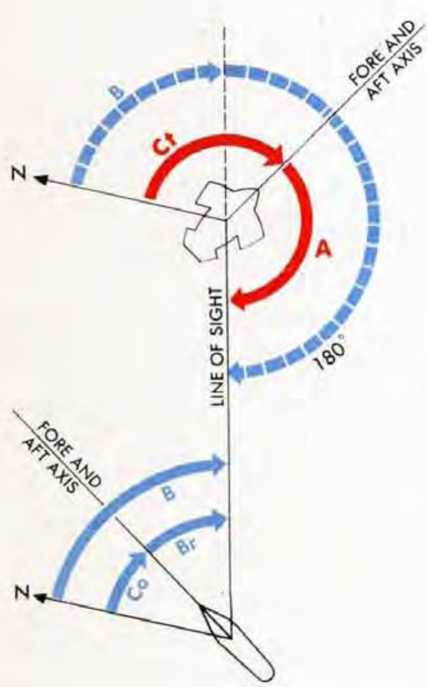
The quantities which must be computed for use by the component solvers are Relative Target Bearing, *Br*, Target Angle, *A*, and Target Elevation, *E*.



Relative Target Bearing, *Br*, is computed by adding Deck Tilt Correction, *jB'r*, to Director Train, *B'r*. Deck Tilt Correction, *jB'r*, is computed in the Deck Tilt Group. Director Train, *B'r*, is transmitted electrically from the Director to the *B'r* Receiver. Deck Tilt Correction, *jB'r*, is added to Director Train, *B'r*, at differential D-9, to obtain Relative Target Bearing, *Br*.

Target Angle, *A*, is the horizontal angle between a vertical plane through the fore and aft axis of the Target and a vertical plane through the Line of Sight, measured clockwise from the bow of the Target.

The value of *A* is computed as $B + 180^\circ - Ct$. *B* is True Target Bearing and *Ct* is Target Course.

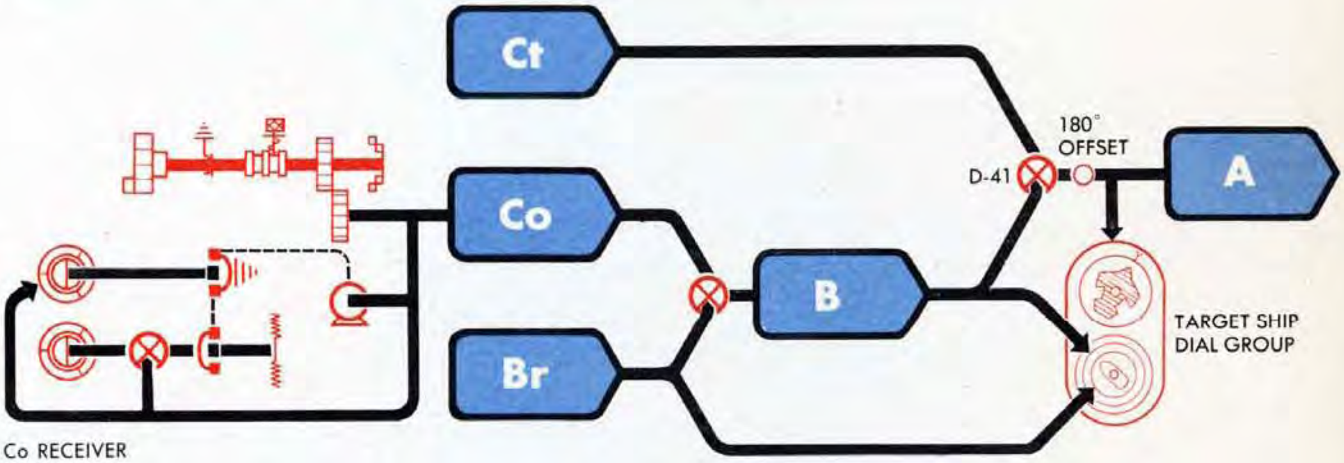


True Bearing, *B*, is the horizontal angle between a North-South vertical plane and the vertical plane through the Line of Sight, measured clockwise from North. The value of *B* is computed by adding Relative Target Bearing, *Br*, to Ship Course, *Co*.

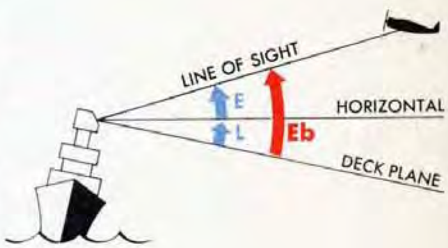
Ship Course, *Co*, is the horizontal angle between a North-South vertical plane and the vertical plane through the fore and aft axis of Own Ship, measured clockwise from North to the bow of Own Ship. The value of *Co* is either received electrically at the *Co* Receiver or is put in by hand at the Ship Course Handcrank.

Br is added to *Co* at differential D-26. The differential output is True Bearing, *B*.

Target Course, *Ct*, is the horizontal angle between the North-South vertical plane and a vertical plane through the direction of motion of the Target, measured clockwise from North to the bow of the Target. *Ct* is estimated and set into the Computer through the Target Angle Handcrank. At differential D-41, the value of *Ct* is subtracted from *B*. The 180° is added to the differential output at a clamp offset. The result is Target Angle, *A*.

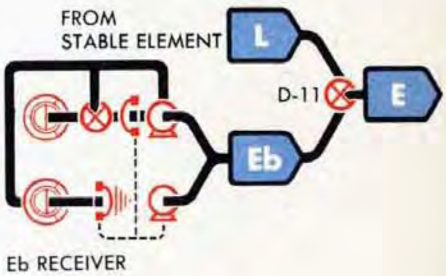


Target Elevation, *E*, is the last of the component solver inputs which need to be computed. *E* is the angle between the horizontal and the Line of Sight, measured in a vertical plane through the Line of Sight.



Director Elevation, *Eb*, is the angle between the deck plane and the Line of Sight, measured in a vertical plane through the Line of Sight. *Eb* is transmitted electrically from the Director to the *Eb* Receiver in the Synchronize Elevation Group. Level, *L*, is transmitted to the Computer by a shaft line from the Stable Element. *L* is subtracted from *Eb* at differential D-11 in the Synchronize Elevation Group to obtain Target Elevation, *E*.

The speed inputs to the component solvers, *So*, *Sh*, and *dH*, need no initial computation inside the Computer.

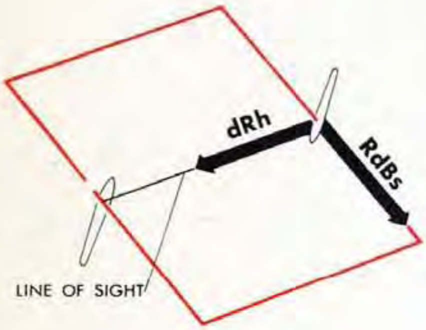


Ship Speed, *So*, is transmitted electrically from the Pitometer Log to the *So* Receiver or set in by hand.

Target Horizontal Ground Speed, *Sh* is estimated and set into the Computer through the Target Speed Handcrank.

Rate of Climb, *dH*, the vertical speed of the Target, can also be estimated and is set into the Computer through the Rate of Climb Crank.

Relative motion for a SURFACE target

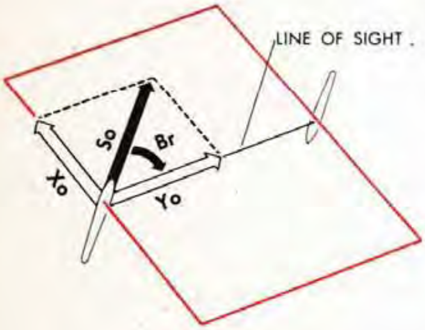


For the sake of clarity, this discussion of Relative Motion for a surface target assumes that the Line of Sight lies in a horizontal plane at the level of the Director. Actually the Line of Sight to a surface target is slightly depressed. If the Line of Sight is assumed to be horizontal, only two Relative Motion Rates are computed. They are:

Horizontal Range Rate, *dRh,* along the Line of Sight

Deflection Rate, *RdBs,* at right angles to the Line of Sight.

The Rates *dRh* and *RdBs* are obtained from Components of Ship Velocity and Target Velocity, computed by the Ship and Target Component Solvers.



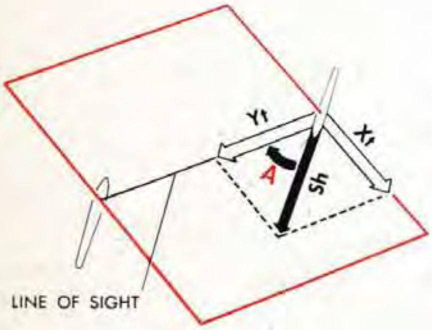
The Ship Component Solver

The Ship Component Solver is a cam-type component solver. Component solvers are described in detail in OP 1140. The inputs are Own Ship Speed, *So,* and Relative Target Bearing, *Br. So* positions the cam and *Br* positions the vector gear.

The outputs are:

1 The Component of Ship Velocity, *Yo,* along the horizontal Line of Sight, called the Range Component.

2 The Component of Ship Velocity, *Xo,* at right angles to the Line of Sight in the horizontal plane, called the Deflection Component.



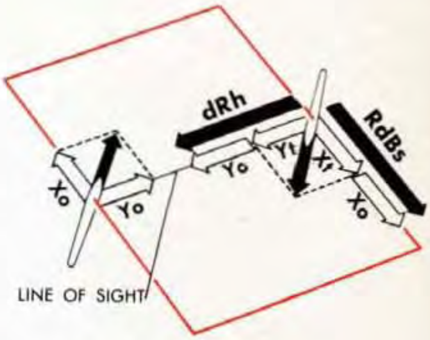
The Target Component Solver

The Target Component Solver is also a cam-type component solver. The inputs are Horizontal Target Speed, *Sh,* and Target Angle, *A. Sh* positions the cam and *A* positions the vector gear.

The outputs are:

1 The Component of Horizontal Target Velocity, *Yt,* along the horizontal Line of Sight, called the Range Component.

2 The Component of Horizontal Target Velocity, *Xt,* at right angles to the Line of Sight in the horizontal plane, called the Deflection Component.



The Range Components, *Yo* and *Yt*, are now combined to obtain Horizontal Range Rate, *dRh*.

$$dRh = Yo + Yt$$

In this diagram, *Yo* and *Yt* are negative because the motion of both Own Ship and Target is decreasing the Range. The value of *dRh* is therefore negative, indicating a *closing* Range Rate.

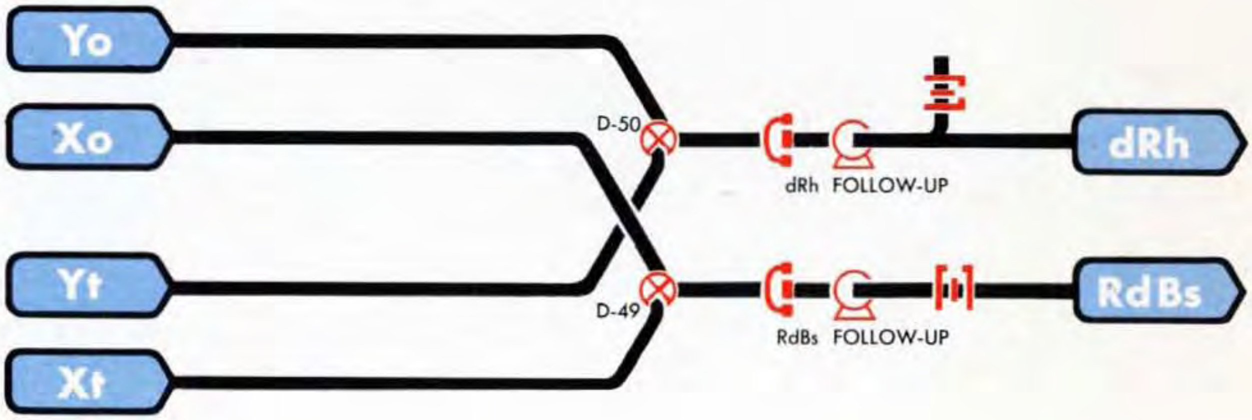
In the same way, the Deflection Components, *Xo* and *Xt*, are combined to obtain Deflection Rate, *RdBs*.

$$RdBs = Xo + Xt$$

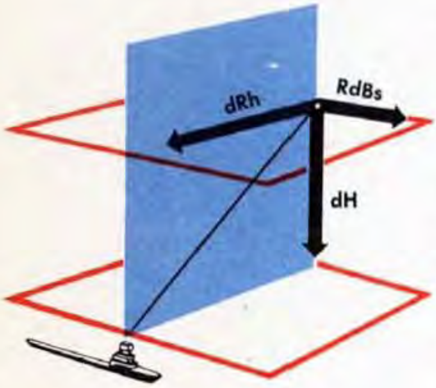
In the diagram, *Xo* and *Xt* are positive because the motion of both Own Ship and Target is causing the Line of Sight to deflect to the right. Deflection of the Line of Sight to the right is considered positive because it increases Bearing.

Both *dRh* and *RdBs* are amplified by follow-ups. These are energized whenever the Computer Power Switch is ON.

Since the Relative Motion Rates are rates of change of Target Position as viewed from Own Ship, the rates are usually drawn as though Own Ship were stationary and all the motion were at the Target.



Relative motion for an AIR target



Up to this point, Relative Motion Rates have been computed only in the horizontal plane at the level of Own Ship's Director.

For air targets, the Line of Sight is elevated above this horizontal plane. Calculations must be made in three planes:

1. The horizontal plane at the level of the Director of Own Ship.
2. The vertical plane through the Line of Sight.
3. The horizontal plane at the level of the air target.

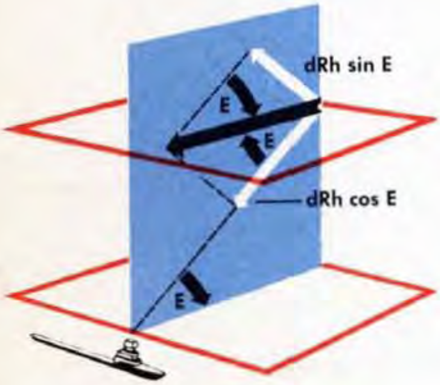
As in the case of the surface target, the Ship and Target Component Solvers are used to produce Horizontal Range Rate, *dRh*, and Deflection Rate, *RdBs*.

RdBs is one of the three final Relative Motion Rates needed for an air target.

Horizontal Range Rate, *dRh*, is used together with Rate of Climb, *dH*, to compute the other two rates needed:

1. Direct Range Rate, *dR*, the Relative Motion Rate along the Line of Sight between Own Ship and Target.
2. Elevation Rate, *RdE*, the Relative Motion Rate perpendicular to the Line of Sight in the vertical plane through the Line of Sight.

The dRh component solver



The Components of *dRh* are computed in the vertical plane through the Line of Sight.

Since *dRh* may be either positive or negative, a screw-type component solver is used. The input to the screw is *dRh*. The input to the vector gear is Target Elevation, *E*.

The outputs are:

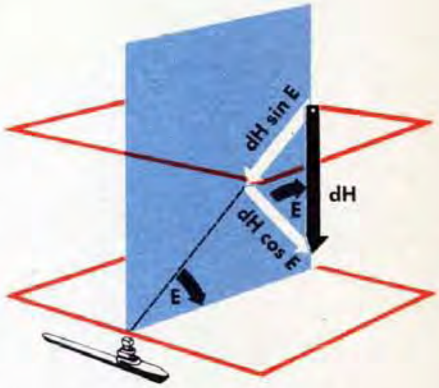
1. The Component of *dRh* directly along the Line of Sight, *dRh* cos *E*.
2. The Component of *dRh* perpendicular to the Line of Sight in the vertical plane through the Line of Sight, *dRh* sin *E*.

The dH component solver

Rate of Climb, *dH*, is the vertical component of the Target's actual speed. *dH* is positive when the Target is climbing, and negative when the Target is diving.

Since *dH*, like *dRh* can be either positive or negative, the *dH* Component Solver is a screw-type component solver.

The inputs to the *dH* Component Solver are Rate of Climb, *dH*, and Target Elevation, *E*. *dH* positions the screw and *E* positions the vector gear.

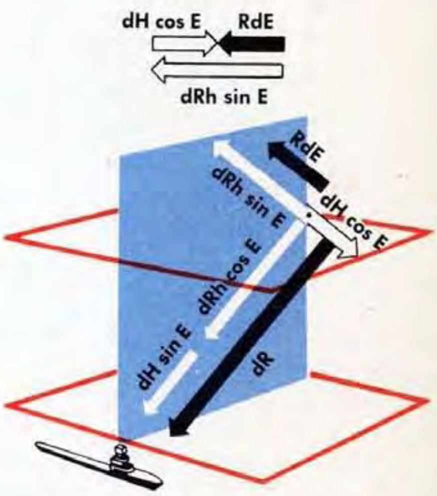


The outputs are:

1 The component of *dH* along the Line of Sight, *dH* sin *E*.
2 The component of *dH* perpendicular to the Line of Sight, *dH* cos *E*.

Computing dR and RdE

The *dH* Component Solver and the *dRh* Component Solver produce two pairs of components.

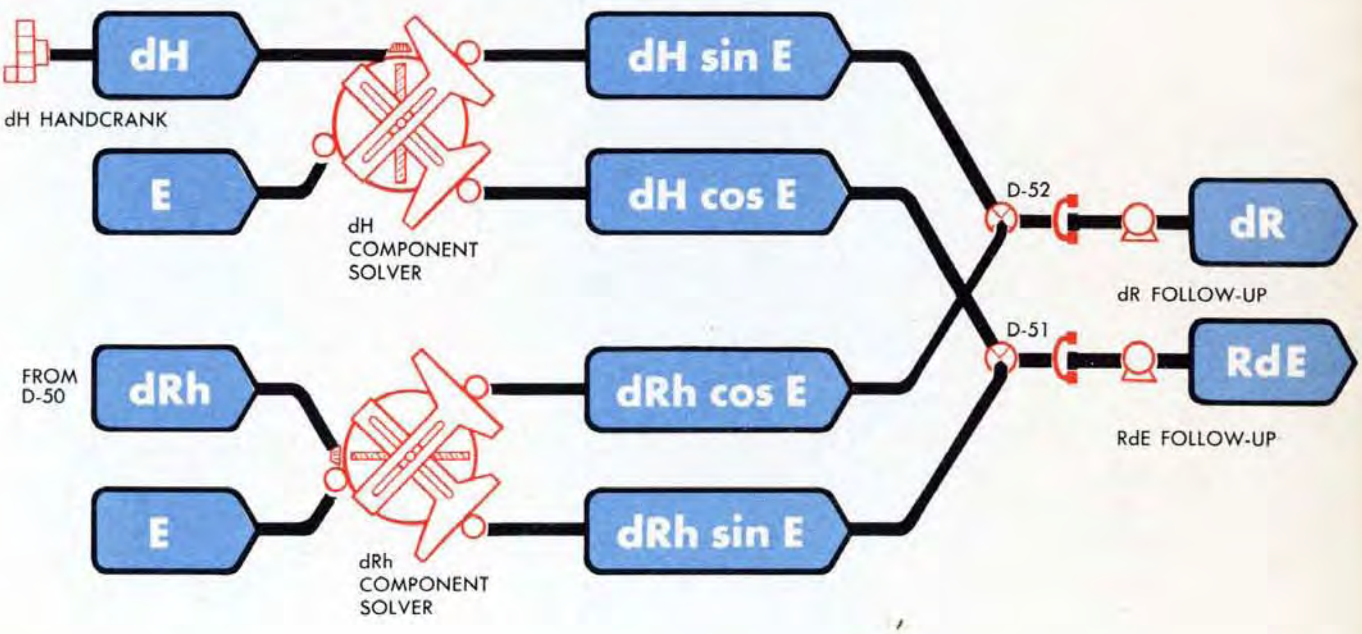


The Components along the Line of Sight are combined at differential D-52 to obtain Direct Range Rate, *dR*.

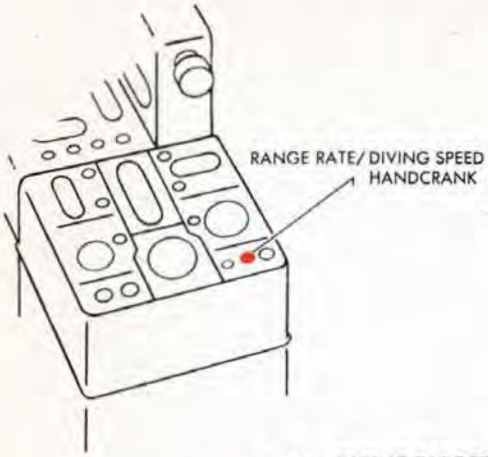
The Components perpendicular to the Line of Sight in the vertical plane are combined at differential D-51 to obtain Linear Elevation Rate, *RdE*.

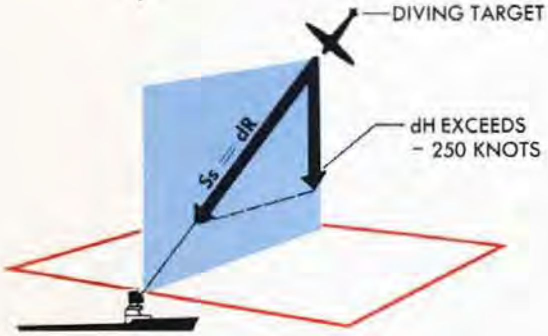
Direct Range Rate, *dR*, is positive when Range is increasing. Linear Elevation Rate, *RdE*, is positive when Elevation is increasing. In this diagram, *dR* is negative and *RdE* is positive.

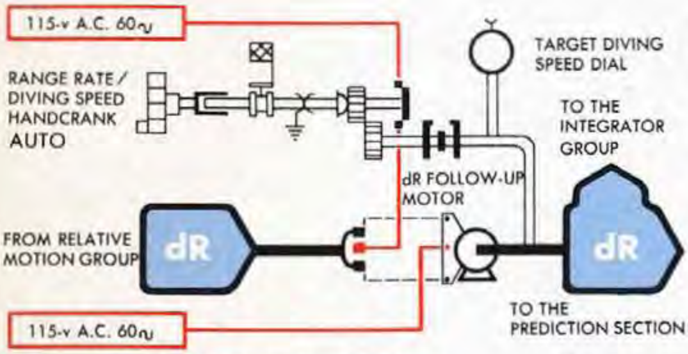
Both *dR* and *RdE* are amplified by velocity-lag follow-ups.



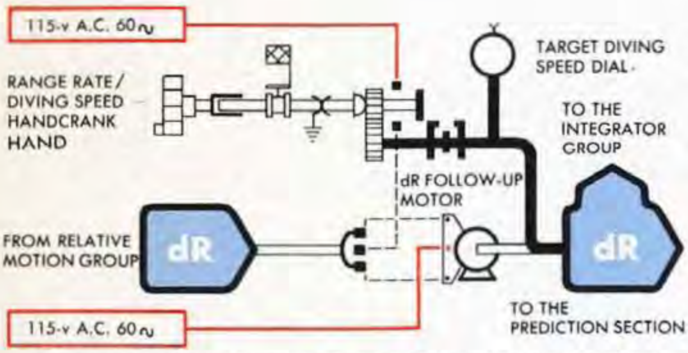
THE RANGE RATE DIVING SPEED HANDCRANK







dR MOTOR DRIVES dR SHAFT LINE



RANGE RATE/DIVING SPEED HANDCRANK DRIVES dR SHAFT LINE

The Range Rate/Diving Speed Handcrank is located on top of the Computer Mark 1, to the right of the Range Dials. This handcrank can be used during a dive attack against Own Ship.

A Target diving at Own Ship is assumed to be diving almost along the Line of Sight. When a Target is diving along the Line of Sight, the actual Target Diving Speed, *Ss*, is approximately the same as Direct Range Rate, *dR*. Under these conditions *dR* will have a very high value, and *RdE* and *RdBs* will contain only very small Target Motion Components because most of the Target Motion is down the Line of Sight.

The Relative Motion Group cannot compute the full value of *dR* during this type of attack when both the Target Speed and Elevation are such that *dH* exceeds −250 knots. A limit stop on the *dH* line prevents the negative value of *dH* from exceeding −250 knots.

A Special Diving Attack Procedure is generally used when the Target Diving Speed along the Line of Sight causes Rate of Climb, *dH*, to exceed −250 knots. The Range Rate/Diving Speed Handcrank is then used to reposition the *dR* line quickly at the full value of Diving Speed, *Ss*.

The Range Rate/Diving Speed Handcrank has two positions: AUTO and HAND.

In normal operation, the handcrank shift lever is at AUTO. The handcrank is disengaged from the *dR* shaft line and the *dR* line is driven by the values of *dR* computed in the Relative Motion Group.

During Special Dive Attack Procedure, the handcrank shift lever is switched to HAND. The handcrank drive gear is meshed with a gear on the *dR* shaft line. Shifting the lever to HAND also depresses a push-button switch which breaks the electrical circuit to the *dR* Follow-up Motor. With the handcrank at the HAND position, the *dR* Follow-up Motor is de-energized and the Range Rate/Diving Speed Handcrank is connected to the *dR* shaft line.

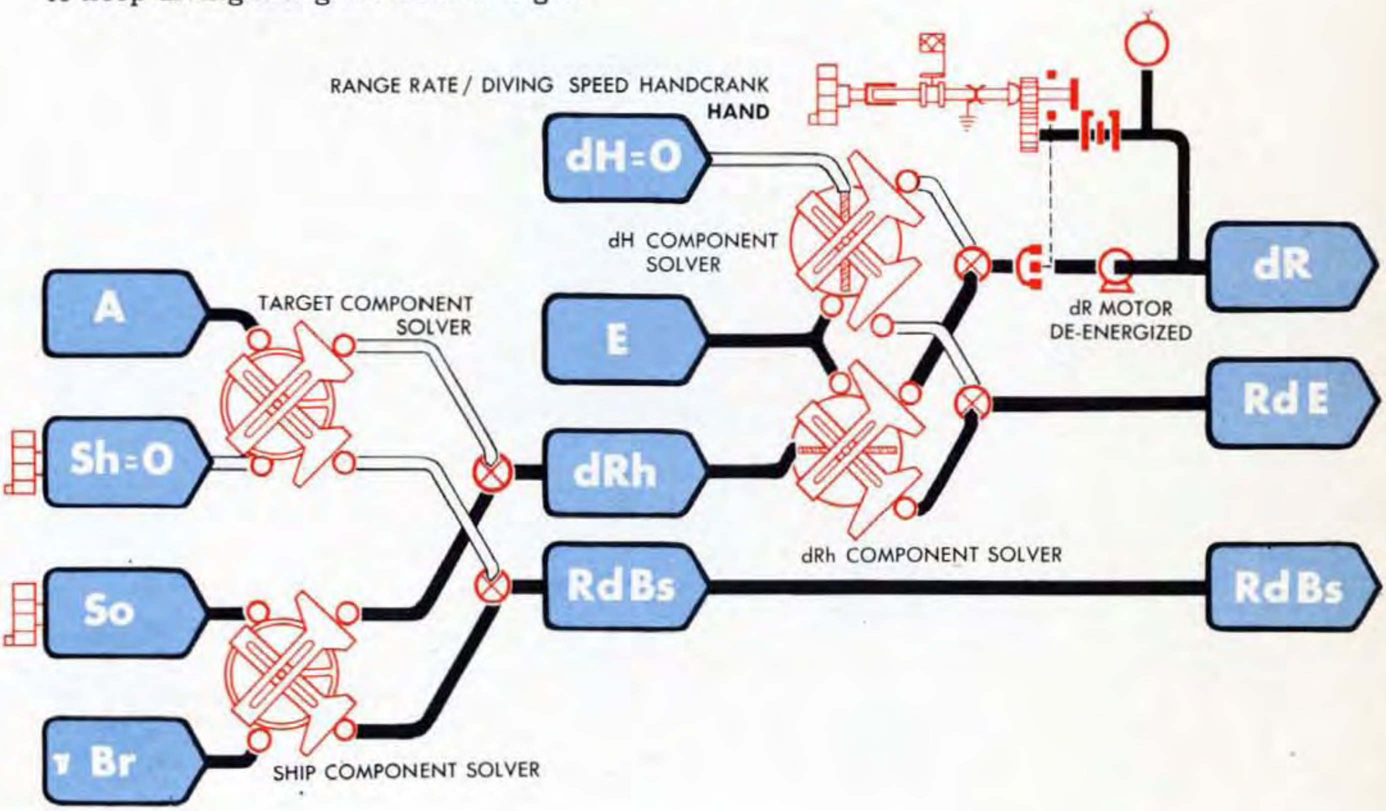
How the handcrank is used

As soon as a Target is observed to be diving at Own Ship with a vertical component of Diving Speed greater than −250 knots, the value of Target Diving Speed, *Ss*, is usually estimated at the Director and phoned to the Computer. At the Computer, Horizontal Target Ground Speed, *Sh*, and Rate of Climb are set at zero. The Range Rate/Diving Speed Handcrank is shifted to HAND to connect it to the *dR* shaft line, and the estimated value of Target Diving Speed, *Ss*, is set in on the Target Diving Speed Dial.

Why dH and Sh are turned to zero

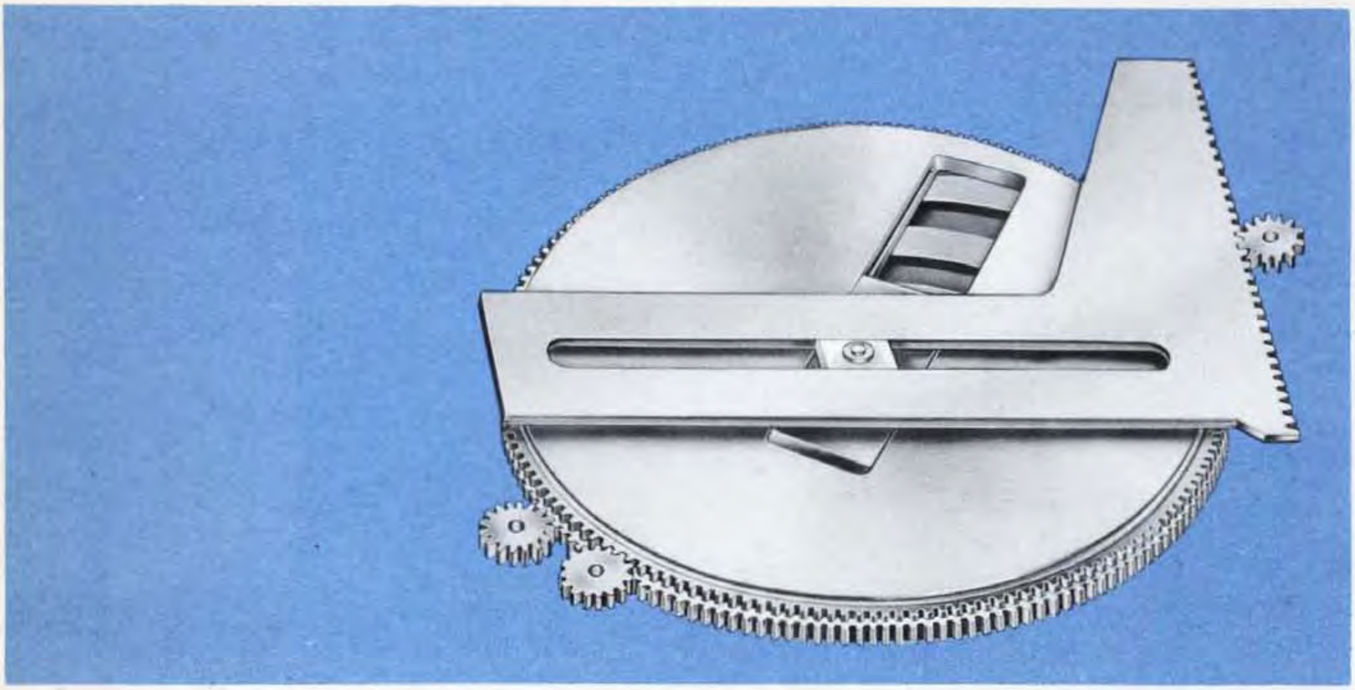
In normal operation, components of Horizontal Target Speed, *Sh*, and of Own Ship Speed, *So*, are combined to obtain Horizontal Range Rate, *dRh*. Components of *dRh* and *dH* are combined to obtain *dR* and *RdE*. In Special Dive Attack Procedure, *dR* is put into the Computer by hand through the Range Rate/Diving Speed Handcrank, and components of *dH* and *dRh* are therefore not needed. For this reason, *dH* and *Sh* are turned to zero. *dRh*, then, contains only the component of Own Ship Speed.

The values of *RdE* and *RdBs* are usually close to zero because as Own Ship moves the Target continuously adjusts its course to keep diving along the Line of Sight.



Quick Reference Index

The HEIGHT COMPUTER



The HEIGHT COMPUTER in the Computer Mark 1 is used to find the Height, *H*, of the Target.

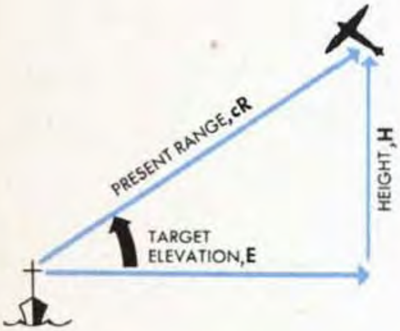
The Height Computer positions the Height Dials. Although Height is not actually used in computing Gun Orders, it is sometimes needed in finding *Present Range* or *Target Elevation*.

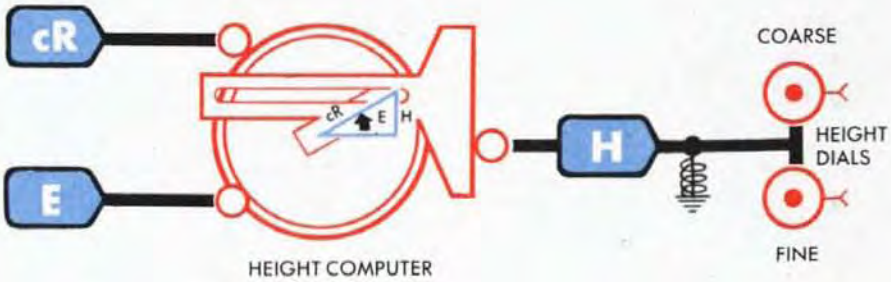
The Height Computer is a cam-type component solver with only one output rack. It is located on top of the Relative Motion Component Solvers.

The two inputs to the Height Computer are Generated Present Range, *cR*, which positions the cam, and Target Elevation, *E*, which positions the vector gear.

The output is *cR* sin *E*, which is equal to Target Height, *H*.

The output, *H*, goes directly to the Height Dials.





How height is used to find range

Suppose that a shore battery is being shelled. The height of the battery is known from a map, but the range is not known.

The angle of Elevation is easily found by putting the Pointer's crosshair on the Target.

The Computer Operator can now find the correct Range by turning the Generated Range Crank and watching the Height Dials. When the reading on the Height Dials is equal to the known height of the Target, the value of Present Range in the Computer is correct. The Range is correct because there is only one value of Range possible for each combination of Elevation and Height.

How height is used to find target elevation

If both the Height and the Range of a Target are known, the Target Elevation can be found from these two values.

Suppose a battery which is to be shelled is out of sight over a ridge of hills, but its range and height can be determined with the aid of a contour map. However the sights cannot be put on the Target because the Target is not visible.

Target Elevation can be found by the following method:

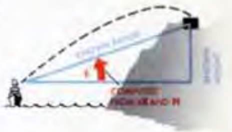
The Operator sets in the calculated value of Range and then reads the Height Dial.

If the Height reading does not correspond to the known height, the angle of Target Elevation must be wrong.

Target Elevation is adjusted until the correct Height reading shows on the Height Dials at the Computer.

When both Range and Height readings are correct, the value of Target Elevation is also correct.

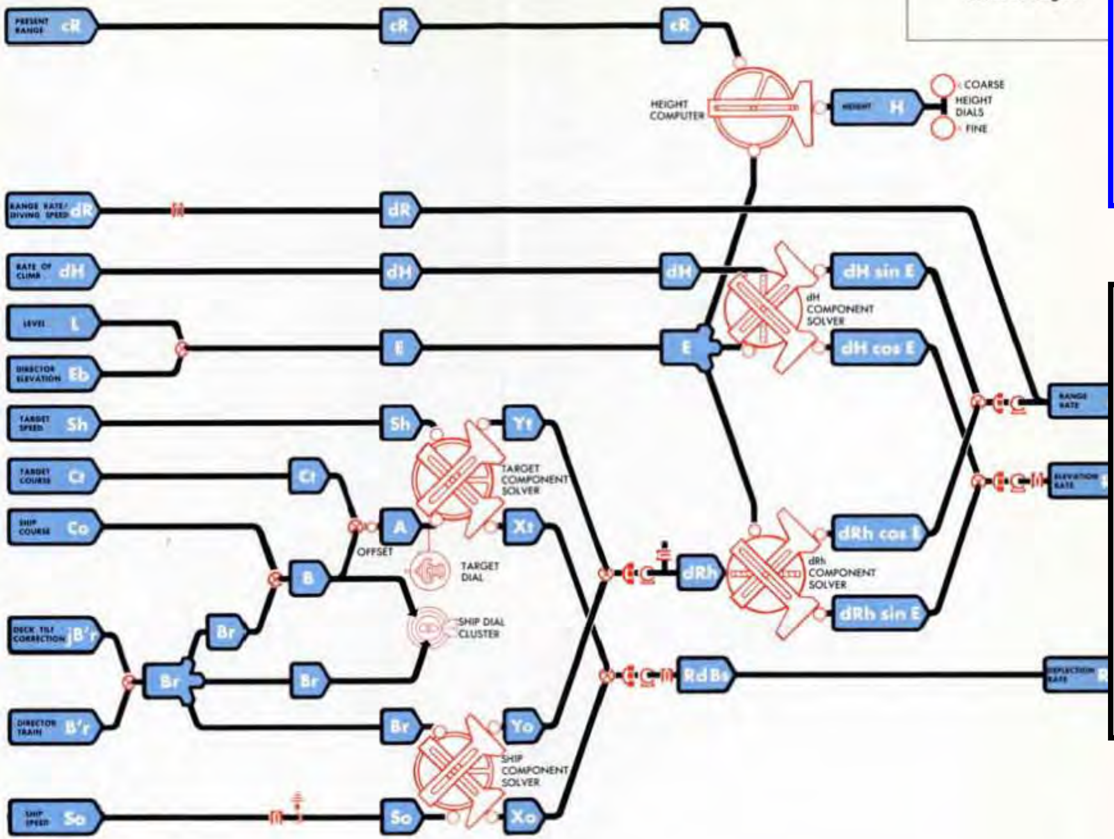
The Height Dials are also used for certain other purposes, as prescribed by *ship's doctrine*.



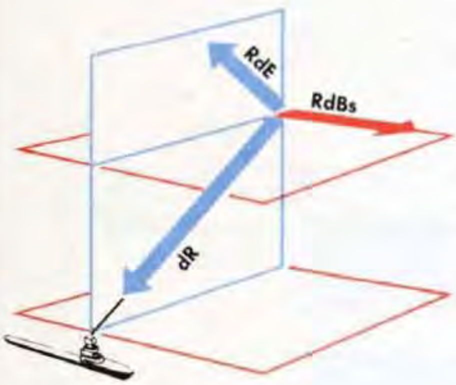
COMPUTER MK 1, MOD 7

RELATIVE MOTION GRO

Schematic Diagram



THE INTEGRATOR GROUP

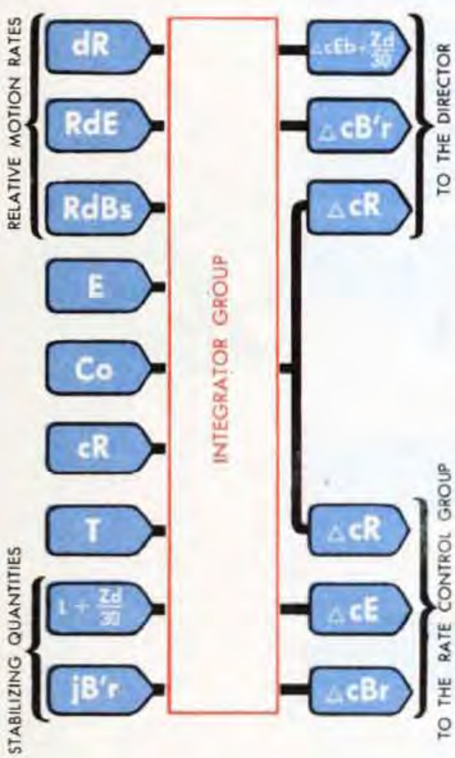


The Integrator Group computes *Linear* Changes of Generated Range, and *Angular* Changes of Generated Elevation and Relative Target Bearing, using the three Relative Motion Rates, *dR*, *RdE* and *RdBs*.

These continuously changing generated values are compared with the continuously changing observed values of Range, Elevation, and Bearing. Any differences between the generated and observed values may be corrected by means of the Rate Control Group.

To compute the Generated Changes of Range, Elevation, and Bearing, the Integrator Group receives the following inputs:

1 Range Rate, *dR*.
2 Linear Elevation Rate, *RdE*.
3 Linear Deflection Rate, *RdBs*.
4 Target Elevation, *E*.
5 Ship Course, *Co*.
6 Generated Present Range, *cR*.
7 Time, *T* (from the Time Motor within the Integrator Group).



Three outputs of the Integrator Group are used to turn the Generated Range, Elevation, and Relative Target Bearing Dials. These outputs are:

1 Generated Changes of Range, $\triangle cR$.
2 Generated Changes of Target Elevation, $\triangle cE$.
3 Generated Changes of Relative Target Bearing, $\triangle cBr$.

Similar generated quantities are also needed in the Director to position the Range Finder and the Pointer's and Trainer's sights.

Since the Generated Changes of Target Elevation and Relative Target Bearing are computed in relation to the horizontal plane, they must be corrected for deck inclination before being sent to the Director.

Stabilizing quantities added to the generated values at differentials in the Integrator Group are:

1 Level Angle plus a function of Cross-level, $L + Zd/30$.
2 Deck Tilt Correction, $jB'r$.

The generated quantities sent by synchro transmission to the Director are:

1 Generated Changes of Range, $\triangle cR$.
2 Generated Changes of Director Elevation, $\triangle cEb + Zd/30$.
3 Generated Changes of Director Train, $\triangle cB'r$.

The Mechanism in the Integrator Group

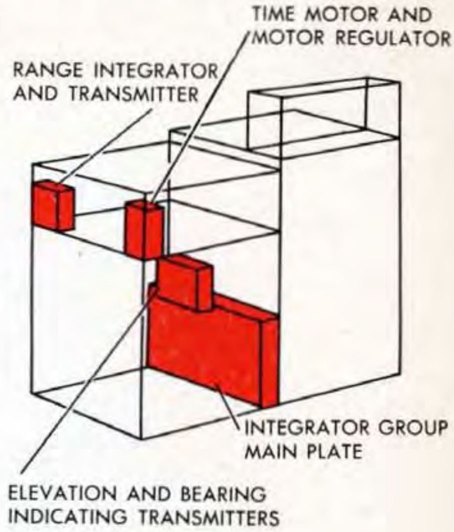
The mechanism in the Integrator Group includes five disk integrators, two cams, the Time Motor, the Time Motor Regulator, five single-speed transmitters, and various differentials.

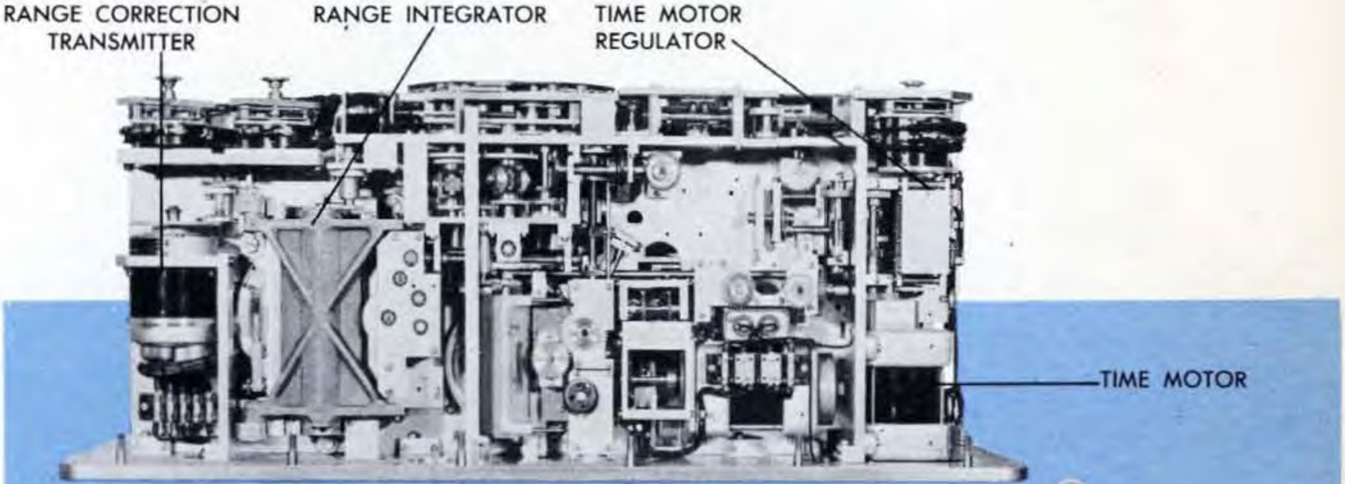
The Range Integrator, the Range Correction Transmitter, the Time Motor, and the Time Motor Regulator can be seen from the front of the Computer Mark 1.

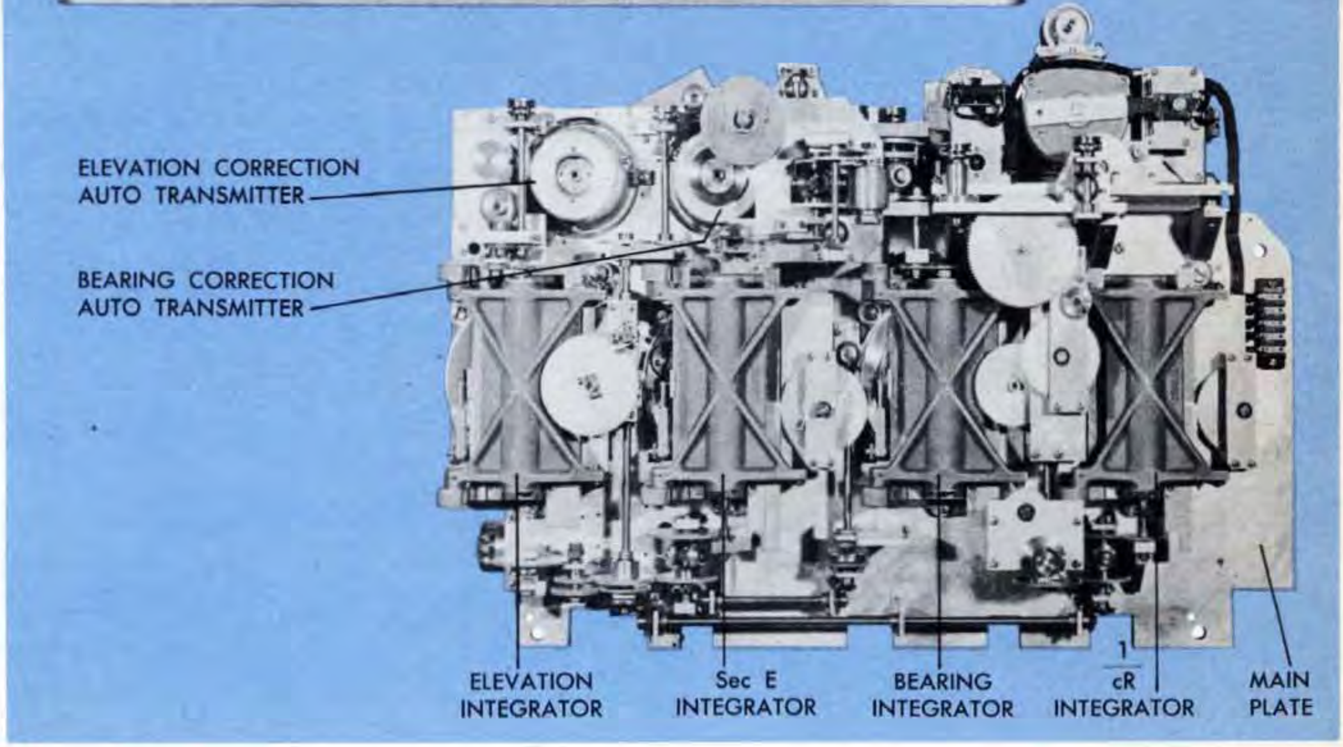
The other four disk integrators can be seen by looking into the lower righthand side of the Computer.

These four integrators, the two cams, and the two transmitters are mounted as a complete unit on a large plate.

The other two transmitters are mounted below the front top section of the Computer.



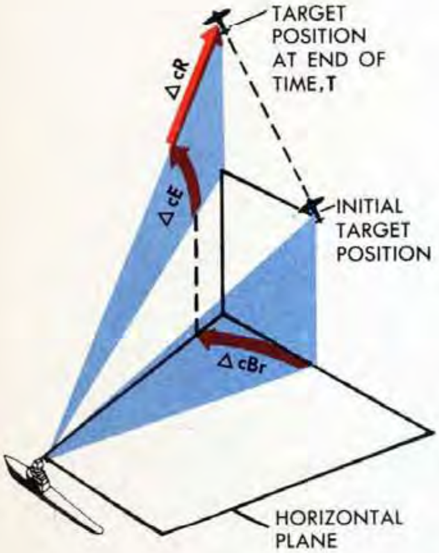




INCREMENTS

The main job of the Integrator Group is to compute continuous values of:

1 Generated Changes of Range, $\triangle cR$
2 Generated Changes of Elevation, $\triangle cE$
3 Generated Changes of Relative Target Bearing, $\triangle cBr$



The three Relative Motion Rates, *dR*, *RdE*, and *RdBs* are continuously multiplied by Time, *T*, in order to generate these three quantities.

Although the Relative Motion Rates change continuously as Own Ship and Target change their courses and speeds, the rates can be thought of as being CONSTANT at any instant.

If a linear rate is thought of as being constant during a short time interval, multiplying the rate by that time interval will give the linear change of Target Position during that time. The changes of Target Position which take place during very short intervals of time are called increments.

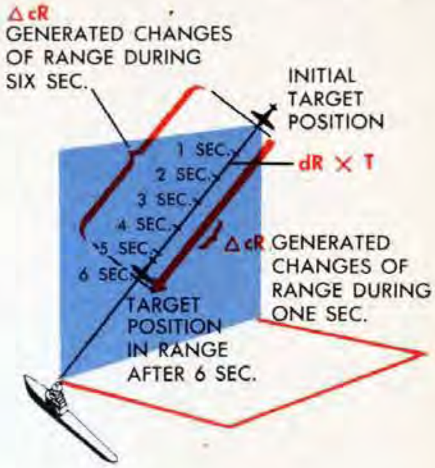
An integrator can be thought of as continuously multiplying a rate, which is constant during very short time intervals, by equally short intervals of time. The product for each time interval is added to the sum of the previous products to produce a total linear change of Target Position.

Increments of Range are *linear* and are generated by the Range Integrator.

Increments of Elevation and Bearing are *angular* and are generated by the Elevation and Bearing Integrators.

How these angular increments are generated from linear rates will be explained in detail later in this chapter.

GENERATED CHANGES OF RANGE



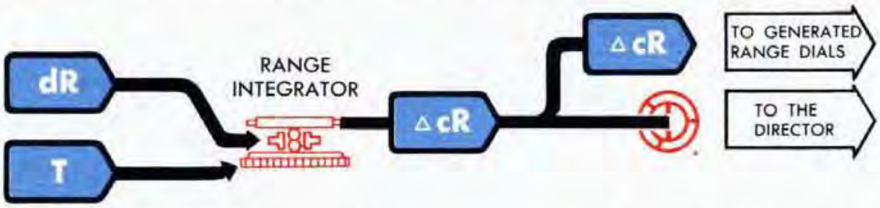
Direct Range Rate, *dR*, indicates the Rate at which Range is changing in yards per minute. To compute the linear Range change during a definite length of time, this equation is used:

LINEAR RATE × TIME = LINEAR DISTANCE

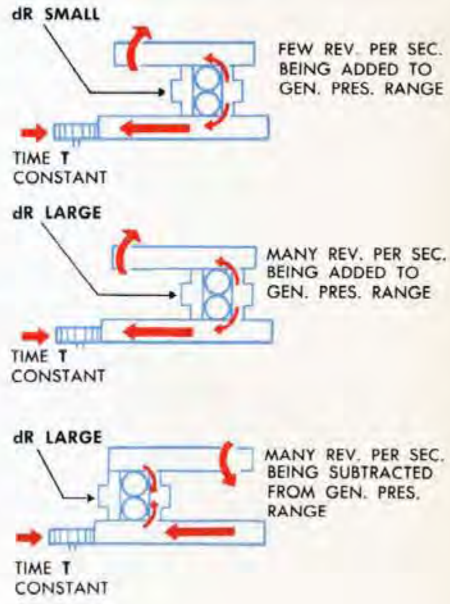
Range Rate, *dR*, × Time, *T*, = Changes of Range, $\triangle cR$, generated during Time, *T*.

The range integrator

The Range Integrator continuously multiplies Range Rate, *dR*, by Time, *T*, to generate the Changes in Range during any time period. Direct Range Rate, *dR*, from the Relative Motion Group positions the carriage of the Range Integrator. Time, *T*, is supplied by the Time Motor. The Time Motor, controlled by the Time Motor Regulator, turns the disk of the Range Integrator at a constant speed. The output from the integrator roller is Generated Changes of Range, $\triangle cR$.



From the moment that the integrator disk starts to rotate, the output roller is continually turning. Sometimes it turns quickly and sometimes it turns slowly. The number of turns of the output roller at any instant compared with the number of turns at any previous time indicates the *size* of the Range increment during that time period. The *speed* at which the roller turns determines *how fast* the increments are being added to or subtracted from previous values of Range. The *direction* in which the roller turns indicates whether Range is *increasing* or *decreasing*, that is, whether increments are being *added to* or *subtracted from* the present value of Generated Range.

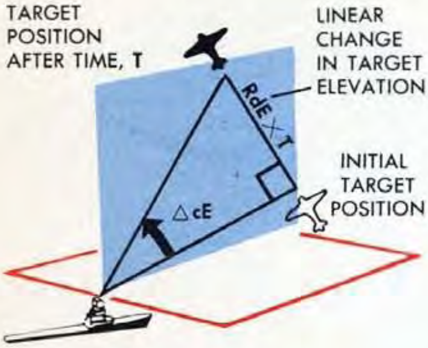


The value of $\triangle cR$ during a small time interval, such as 1/10 second, is the increment of Range Change during 1/10-second based on the value of *dR* during that 1/10-second interval. The value of $\triangle cR$ during a longer time period, such as 10 seconds, is the SUM of the increments generated during the 10-second period, each increment being based on the value of *dR* at the instant at which that increment was being generated. Over any period of time, $\triangle cR$ represents accurate Generated Changes of Range during that time period.

In the Computer, $\triangle cR$ is added to the Initial Range input, *jR*, to give continuous values of Generated Present Range, *cR*. *cR* positions the Generated Range Dials and the Generated Range lines throughout the Computer.

$\triangle cR$ is also transmitted by a single-speed synchro transmitter to the Change of Range Receiver in the Director, to position the Range Finder measuring wedges.

GENERATED CHANGES OF ELEVATION



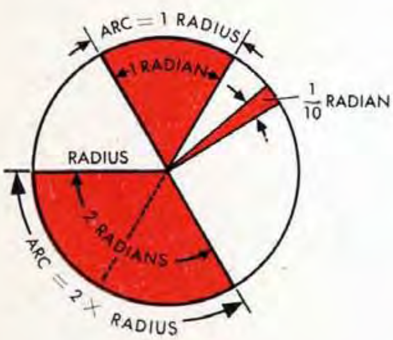
Generated Changes of Target Elevation, $\triangle cE$, are *angular* increments.

If the Linear Elevation Rate, *RdE*, from the Relative Motion Group were multiplied by Time, *T*, the product would be a *linear* change of Target Elevation, $RdE \times T$.

$\triangle cE$ is the angular change of Elevation caused by the Target moving the linear distance $RdE \times T$.

To understand how this *angular* change in Target Elevation is computed from the *linear* Elevation rate, *RdE*, the radian measure of the angles must be understood.

A RADIAN IS THE ANGLE FORMED BY TWO RADII OF A CIRCLE WHEN THE ARC THEY CUT OFF IS AS LONG AS THE RADIUS.

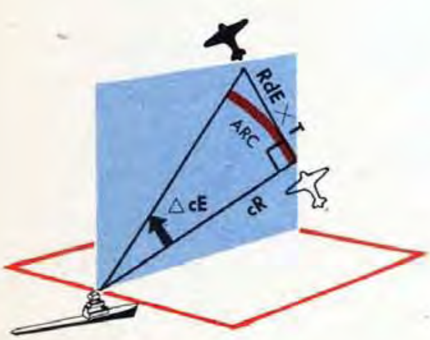


If the arc cut off is 1/10 the length of a radius, the angle equals 1/10 radian.

If the arc cut off is twice the length of a radius, the angle equals two radians.

Any angle may be measured in radians by dividing the length of the arc by the radius:

$$\frac{\text{arc}}{\text{radius}} = \text{angle in radians}$$



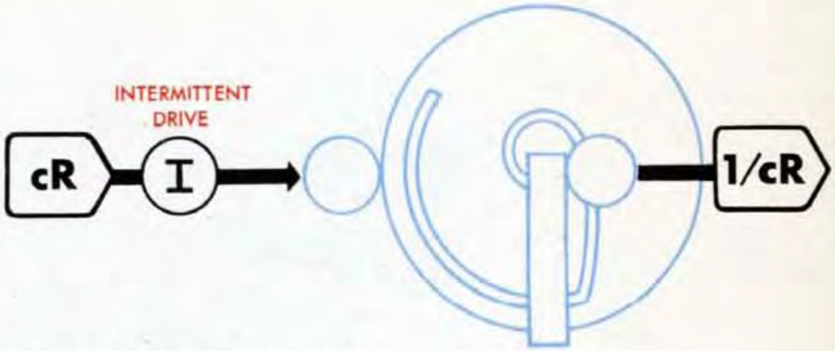
An arc of radius *cR* can be drawn in the vertical plane of sight from the initial Line of Sight to the Line of Sight at the end of Time, *T*.

The line representing the linear change in Target Elevation, $RdE \times T$, is tangent to this arc. If the Time, *T*, is very small, the line $RdE \times T$ can be considered equal in length to the arc.

Dividing the arc by the radius gives angle $\triangle cE$ in radians:

$$\frac{\text{arc}}{\text{radius}} = \frac{RdE \times T}{cR} = \triangle cE$$

This equation can also be written $1/cR \times T \times RdE = \triangle cE$. It is used in this form to compute Generated Changes of Target Elevation, $\triangle cE$, and is solved mechanically by a cam and two disk integrators.



The 1/cR cam

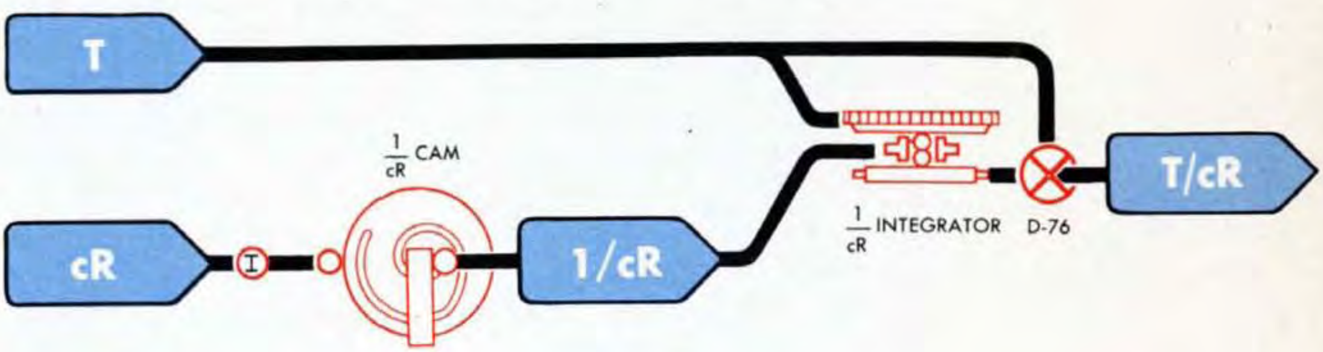
The first term in the $\triangle cE$ equation is obtained from a reciprocal cam. The *1/cR* cam is grooved so that for every input of Generated Present Range, *cR*, the output is the reciprocal of *cR*, or *1/cR*. Multiplying by the reciprocal of *cR* instead of dividing by *cR* reduces the number of mechanisms needed to solve the equation.

The 1/cR integrator

The value *1/cR*, from the *1/cR* cam, positions the carriage of the *1/cR* Integrator. Time, *T*, from the Time Motor drives the integrator disk.

Since *1/cR* is always a positive value, *T* also by-passes the integrator so that the whole width of the integrator disk can be used to obtain more accurate values. (See OP 1140, page 126.) This *T* by-pass is added to the output from the integrator roller at differential D-76 to obtain *T/cR*, the product of the two inputs.

The value of *T/cR* is sent to the Elevation Integrator to complete the computation of $\triangle cE$, and is also used in computing the Generated Changes of Relative Target Bearing, $\triangle cBr$.

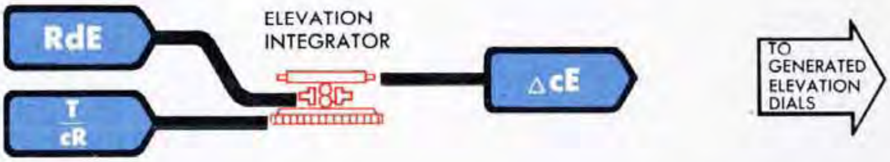


The ELEVATION integrator

With T/cR supplied by the $1/cR$ Integrator and RdE supplied by the Relative Motion Group, the equation $T/cR \times RdE = \triangle cE$ is solved by the Elevation Integrator.

The *inputs* to the Elevation Integrator are Linear Elevation Rate, RdE, which positions the integrator carriage, and T/cR, which turns the integrator disk.

The *output* of the integrator roller is Generated Changes of Target Elevation, $\triangle cE$.



$\triangle cE$ drives the Generated Elevation Dial on top of the Computer. Observed Elevation, E, turns the Observed Elevation Dials in the same dial group so that the Generated Changes of Elevation may be continuously compared with the Observed Changes of Elevation.

In the Director, $\triangle cE$ is used to position the Director Sights and the Range Finder. The Pointer continuously compares the Generated Changes of Elevation with Observed Changes of Elevation.

The Director Sights and Range Finder must also be positioned by the correction $L + Zd/30$. L compensates for the effect of Level; $Zd/30$ allows the Director Sights to be cross-leveled without affecting Director Elevation.

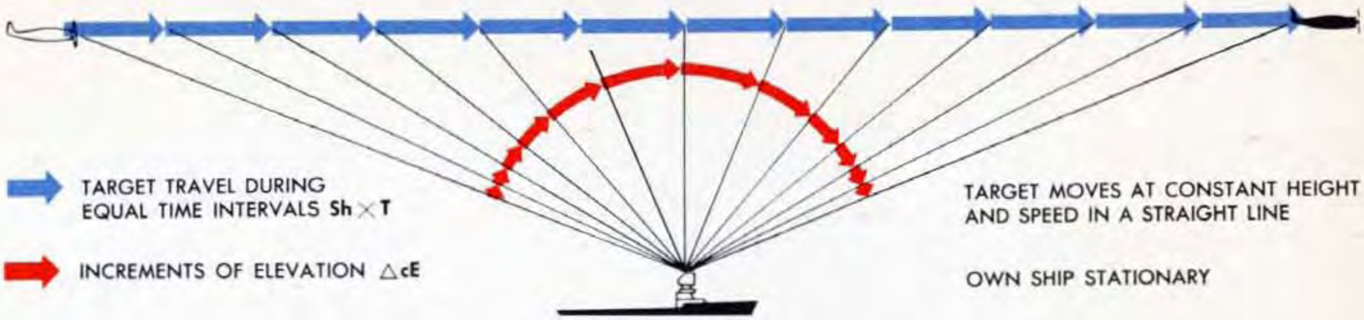
In most installations the value of $L + Zd/30$ is transmitted by shafting from the Stable Element to the Computer and is added to $\triangle cE$ at a differential in the Integrator Group, forming $\triangle cEb + Zd/30$. Then $\triangle cEb + Zd/30$ is transmitted as one quantity to the Director. Two single-speed synchro transmitters, one indicating and one automatic, are used to transmit $\triangle cEb + Zd/30$.

In some installations, $L + Zd/30$ is transmitted to the Director from the Stable Element, and $\triangle cE$ is transmitted from the Computer alone. The two quantities are added in the Director.

In either case, $\triangle cEb + Zd/30$ positions both the Director Sights and the Range Finder in elevation.

When $L + Zd/30$ is transmitted directly from the Stable Element to the Director, the $L + Zd/30$ shaft line going to the Integrator Group is locked by a locking gear.

How increments of elevation vary

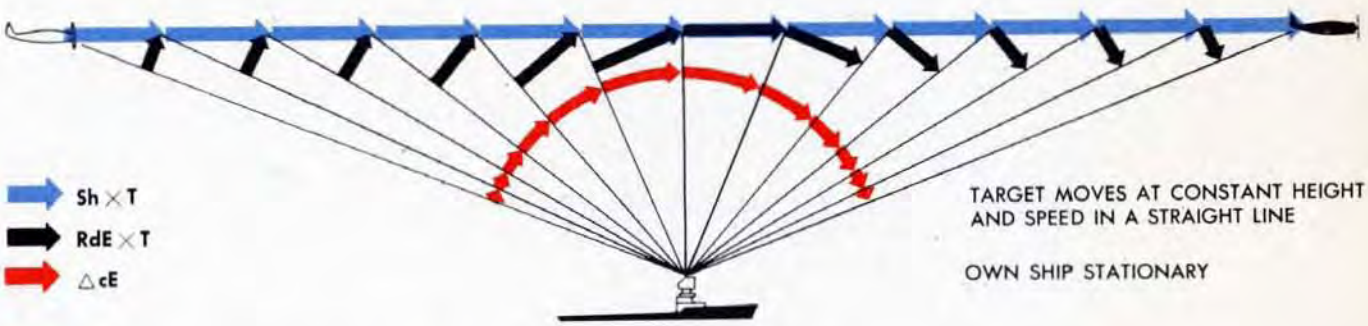


Suppose a Target is moving at a constant height and at a constant speed while Own Ship is stationary, as shown here.

The blue arrows represent linear Target travel during equal time intervals. These arrows are all the same length, since the linear rate is constant.

The red arrows represent the Angular Increments of Elevation needed to position the sights to keep them on the Target during each Time interval. Notice that these increments vary in size.

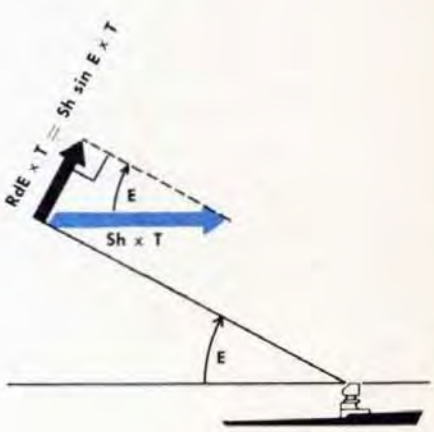
From the instant tracking begins until the Target is directly overhead, the Angular Increments of Elevation for equal Time intervals increase in size. As the Target moves away from Own Ship, the Angular Increments of Elevation begin to decrease for equal Time intervals.



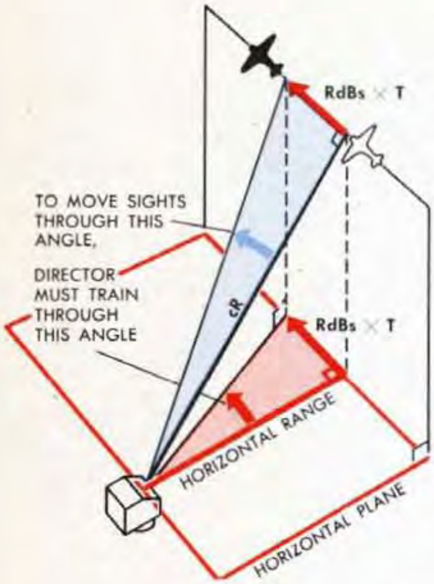
cR varies during the equal Time intervals because Range decreases as the Target approaches Own Ship and increases as soon as the Target has passed over Own Ship and is moving away. $\triangle cE$ varies inversely as cR or directly as $1/cR$.

Since Own Ship is stationary in this example, *RdE* consists only of the component of linear Target velocity lying at right angles to the Line of Sight in the vertical plane. For this special case, *RdE* equals *Sh* sin *E*. *Sh* is constant; therefore *RdE* varies as the sine of *E*. Since *E* increases as the Target approaches Own Ship, and decreases after the Target has passed over Own Ship, *RdE* also increases and then decreases. $\triangle cE$ varies as *RdE* varies.

Then, $\triangle cE = \dfrac{RdE \times T}{cR}$.



GENERATED CHANGES OF TRUE BEARING



The Generated Changes of True Bearing, $\triangle cB$, are angular increments measured in the horizontal plane.

Linear Deflection Rate, $RdBs$, multiplied by Time, T, is the *linear* increment of Deflection during Time, T.

$\frac{RdBs \times T}{cR}$ equals the *Angular* Increments of Bearing in the SLANT plane. In order to be used to train the Director, this angle must be converted to the horizontal plane.

The Angular Increments of Bearing in the horizontal plane, $\triangle cB$, are found by projecting the Lines of Sight and $RdBs \times T$ vertically onto the horizontal plane. One side of the triangle thus formed is the horizontal projection of cR, called Horizontal Range.

$$\triangle cB = \frac{RdBs \times T}{\text{Horizontal Range}}$$

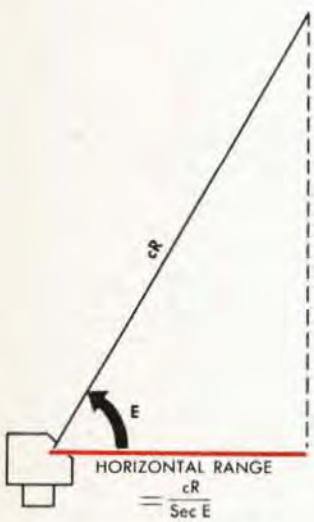
To compute Horizontal Range:

$$\text{Sec } E = \frac{cR}{\text{Horizontal Range}}$$

Therefore:

$$\text{Horizontal Range} = \frac{cR}{\text{Sec } E}$$

$\triangle cB$ is greater than the angle measured by $RdBs \times T$ in the slant plane, because the Horizontal Range is shorter than cR.

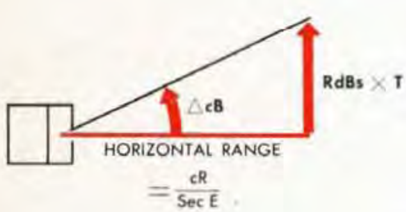


Dividing the linear increments, $RdBs \times T$, by Horizontal Range, $cR/\text{Sec } E$, gives the angular increments, $\triangle cB$ in radians. $\triangle cB$ is the Generated Changes of True Bearing in the HORIZONTAL plane.

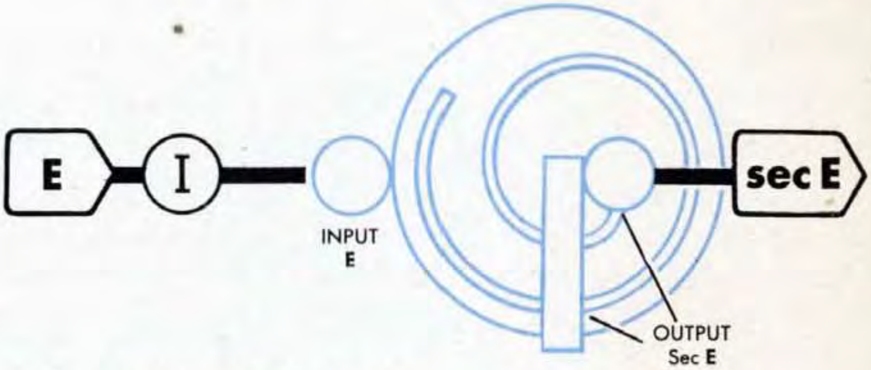
$$\frac{RdBs \times T}{cR/\text{Sec } E} = \triangle cB \text{ in radians}$$

This equation can also be written:

$$\frac{T}{cR} \times \text{Sec } E \times RdBs = \triangle cB$$



The quantity $T/cR \times \text{Sec } E$ is computed mechanically by a cam and an integrator.



The sec E cam

Sec E is computed by a secant cam mounted on the back of the main plate in the Integrator Group.

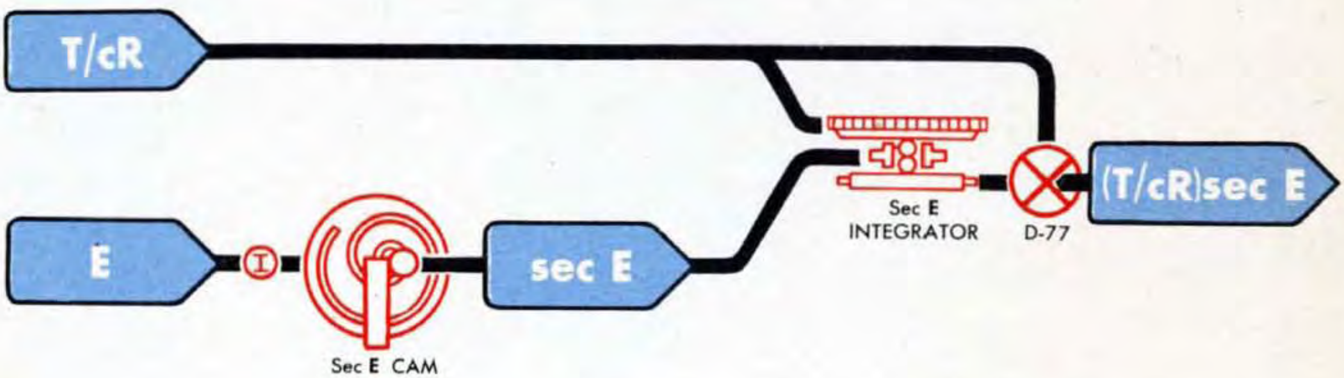
The sec E integrator

Sec E positions the carriage of the Sec E Integrator.

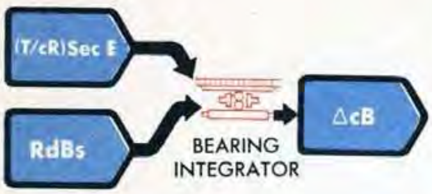
T/cR from the $1/cR$ Integrator drives the disk.

T/cR also by-passes the Sec E Integrator and is added to the roller output at differential D-77. This is done so that the whole width of the integrator disk may be used for positive values of Sec E. The output from D-77 is (T/cR)Sec E, the first part of the equation: $T/cR \times \text{Sec } E \times RdBs = \triangle cB$.

The computation of $\triangle cB$ is completed by multiplying (T/cR) Sec E by $RdBs$. This is done in the Bearing Integrator.

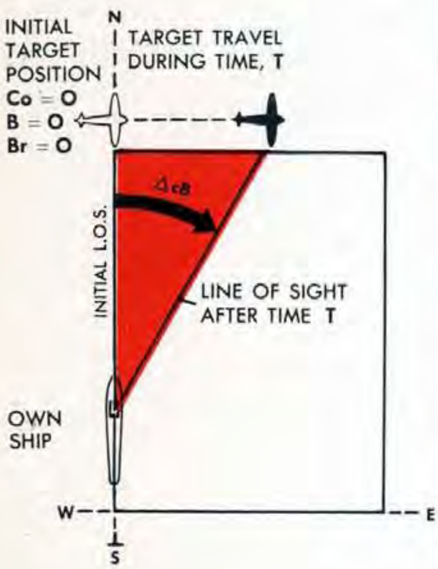


The BEARING integrator



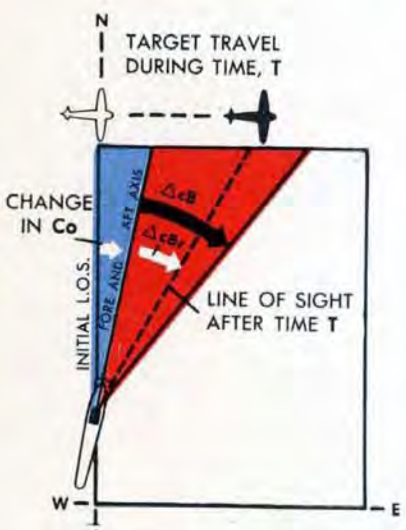
(T/cR)sec E from the Sec E Integrator rotates the disk of the Bearing Integrator. Deflection Rate, $RdBs$, positions the integrator carriage. The output from the roller is Generated Changes of True Bearing, $\triangle cB$.

$\triangle cB$ represents the Changes in *True* Bearing caused by the changes in the position of the Line of Sight. But the Director Sights must be positioned by Changes in *Relative* Target Bearing, in order to keep the sights on Target when Own Ship changes course.



To convert Generated Changes of True Bearing, $\triangle cB$, into Generated Changes of Relative Target Bearing, $\triangle cBr$, the changes in Ship Course, Co, are subtracted from $\triangle cB$. $\triangle cB - Co = \triangle cBr$.

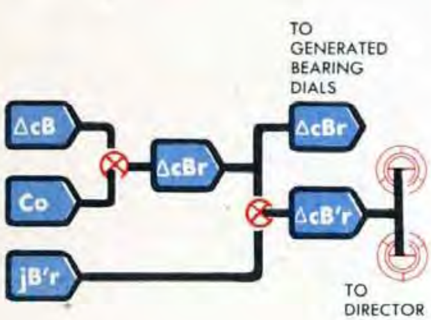
To understand why this is necessary, take a simple example in which Ship Course, *Co*, and True Target Bearing, *B*, are zero. Relative Target Bearing, *Br*, is also zero. The Target is tracked until it moves to the position shown. During this time, the Bearing Integrator computes a value of Generated Changes of True Bearing, $\triangle cB$, which in this case represents the total value of True Bearing, *B*. *Co* remains zero because Own Ship has not changed its course.



Suppose now that Own Ship Course had changed during the same amount of Target travel. The Bearing Integrator would still have computed $\triangle cB$ as the Bearing change between North and the Line of Sight. If the value of $\triangle cB$ were used to position the Director, the sights would be off the Target by the amount of change in Ship Course, *Co*. The angle by which the Director must be positioned is always Relative Target Bearing, the angle between the *fore and aft axis of Own Ship* and the Line of Sight.

To obtain Generated Changes of *Relative* Target Bearing, $\triangle cBr$, Ship Course, *Co*, must be subtracted from Generated Changes of *True* Bearing, $\triangle cB$.

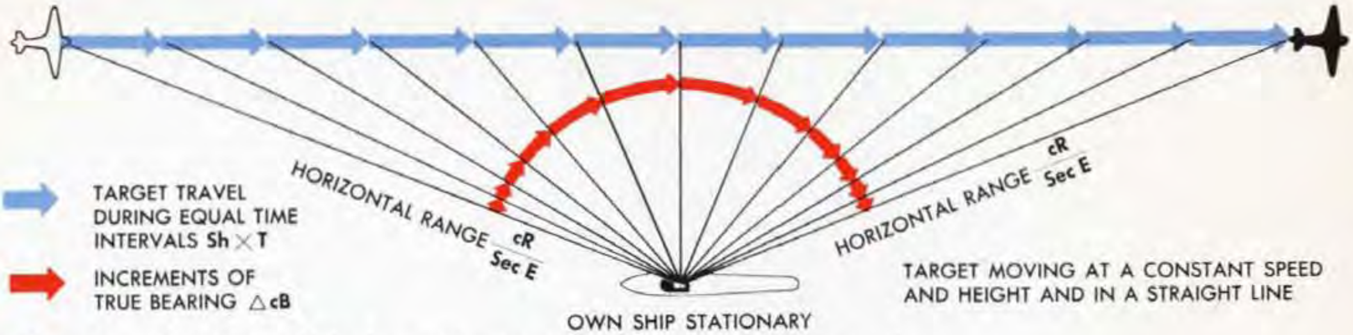
In the example shown, $\triangle cBr$ represents the total value of Relative Target Bearing, *Br*. $\triangle cBr$ positions the Generated Bearing Dial on top of the Computer.



Before $\triangle cBr$ is transmitted to the Director, it must be corrected to compensate for Deck Tilt, since the Director trains in the deck plane. The correction for Deck Tilt, $jB'r$, is computed by the Deck Tilt Group. Generated Changes of Relative Target Bearing in the horizontal plane, $\triangle cBr$, minus Deck Tilt Correction, $jB'r$, equal Generated Changes of Director Train, $\triangle cB'r$. $\triangle cBr - jB'r = \triangle cB'r$.

$\triangle cB'r$ is continuously transmitted to the Director to drive the whole Director in train. Two single-speed synchro transmitters, one indicating and one automatic, are used to transmit $\triangle cB'r$.

How the angular bearing increments vary



Suppose that Own Ship is stationary with the deck steady and horizontal. A Target is moving in a straight line at a constant height and at a constant speed as shown here. The blue arrows represent equal linear increments of Target Motion, $Sh \times T$, for equal intervals of Time. The red arrows represent the angular increments of Bearing, $\triangle cB$, needed to keep the sights on the Target during each time interval.

From the moment tracking begins until the Target is exactly abeam of Own Ship, the angular increments of Bearing, $\triangle cB$, increase in size, although the linear increments of Target Motion are equal. As the Target passes abeam of Own Ship and begins to move away, the angular increments begin to decrease in size.

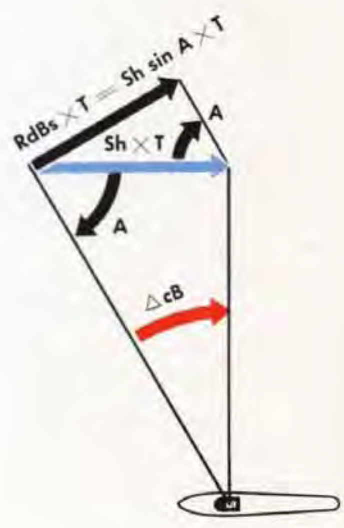
The diagram shows that $\triangle cB$ varies *inversely* as Horizontal Range, $cR/\sec E$, varies, which is *directly* as the reciprocal of $cR/\sec E$ varies.

Since Own Ship is stationary in this example, *RdBs* consists only of the component of Horizontal Target Velocity lying horizontally at right angles to the Line of Sight.

$$RdBs = Sh \sin A$$

Since *Sh* is constant, *RdBs* varies as $\sin A$ varies. Although Target Angle, *A*, increases continuously during the flight of the Target, $\sin A$ increases only until *A* is 90° and then $\sin A$ decreases. *RdBs* varies as $\sin A$ varies. Therefore $\triangle cB$ varies directly as *RdBs* varies.

Then $\triangle cB = \dfrac{RdBs \times T \times \sec E}{cR}$

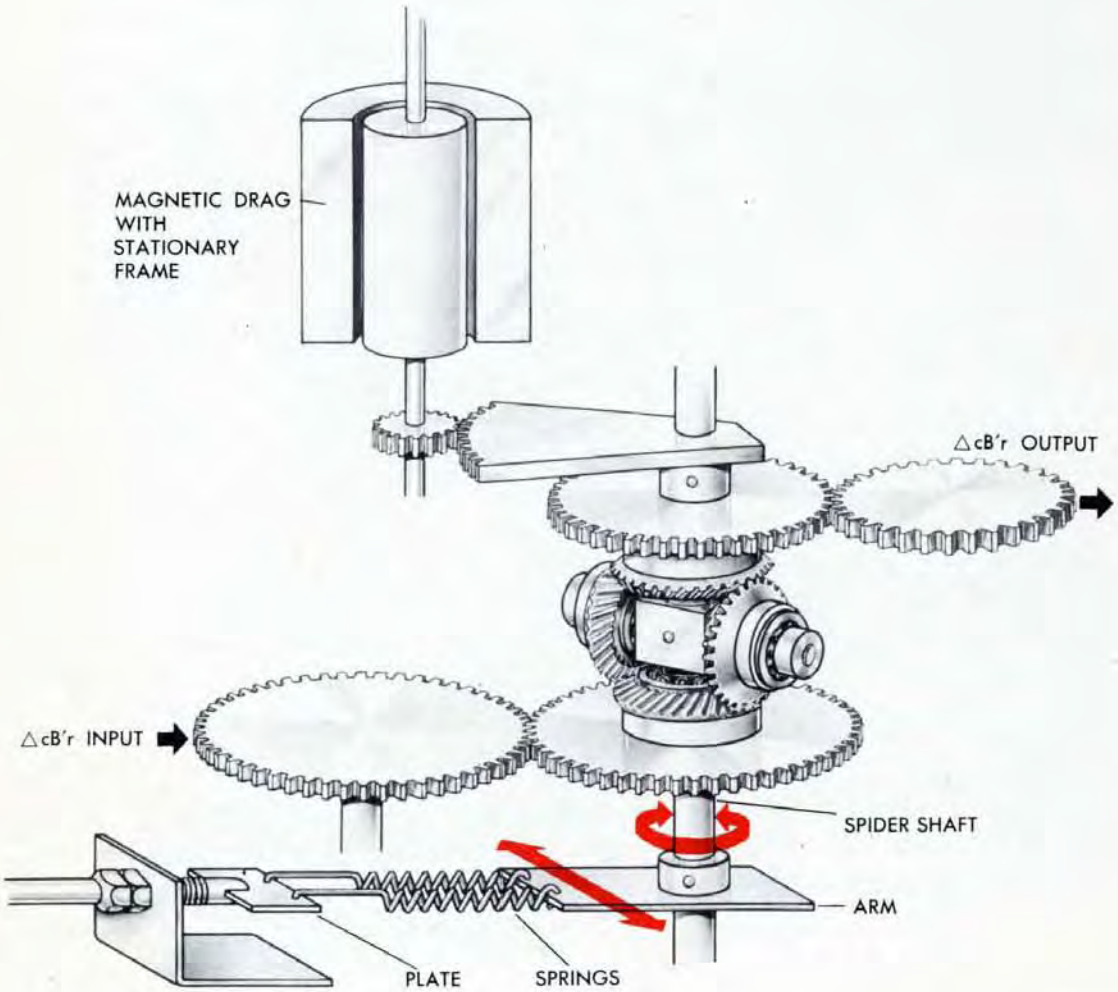


THE BEARING FILTER

The entire Director is trained by the quantity $\triangle cB'r$, transmitted from the Integrator Group in the Computer. The value of $\triangle cB'r$ must therefore change smoothly to avoid jerking the Director. The roughness on the $\triangle cB'r$ shaft line is likely to come from the value of Own Ship Course, *Co*. The Ship Course Receiver in the Computer Mark 1 is provided with a special damper to smooth out the *Co* signal. In addition, a special mechanism is installed on the $\triangle cB'r$ shaft line to prevent any possible roughness on the *Co* shaft line from affecting $\triangle cB'r$. This mechanism is called the Bearing Filter.

The parts of the bearing filter

The Bearing Filter consists of a differential, an arm assembly, and a magnetic drag. The magnetic drag is geared to the differential spider shaft. The arm assembly consists of an arm which is attached to the differential spider shaft, and two springs which connect the end of this arm to a small plate held by a threaded shaft. The threaded shaft is secured to a vertical plate.

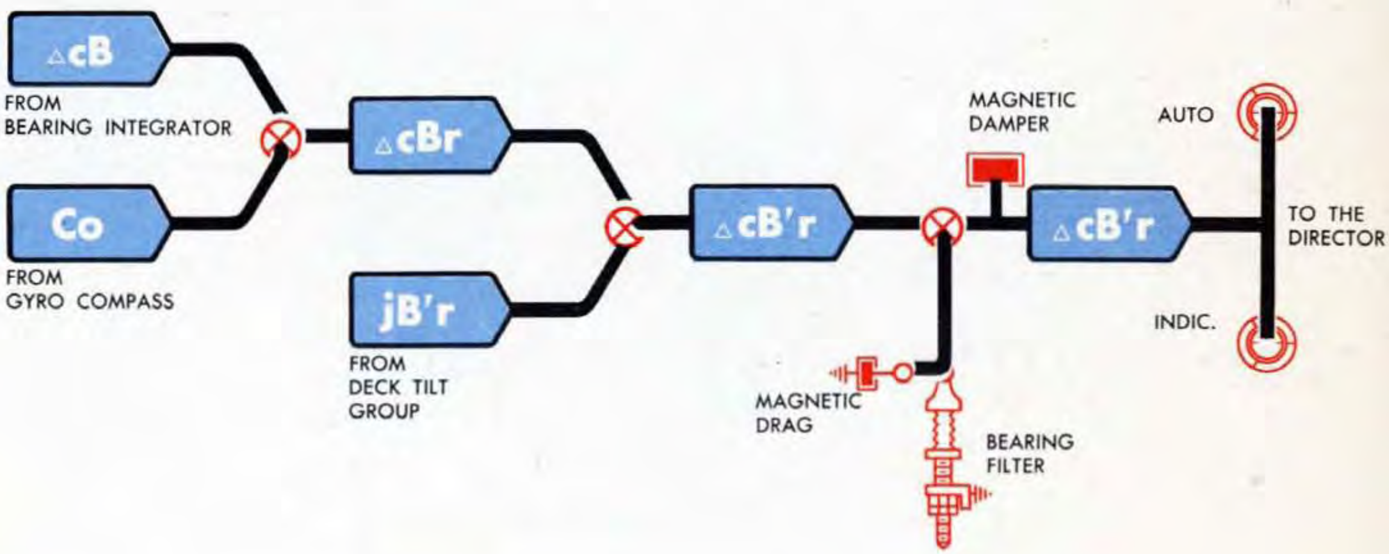


How the bearing filter works

$\triangle cB'r$ is both the input and the output of the differential. When the value of $\triangle cB'r$ changes smoothly, it feeds into one side of the differential and out of the other side while the spider shaft is held stationary by spring tension on the arm.

When tne $\triangle cB'r$ input is rough or reverses direction suddenly, the normal inertia of the $\triangle cB'r$ output shaft line causes it to resist sudden changes of speed and to tend to continue turning at the old speed. An additional force is therefore exerted on the differential spider shaft, causing it to rotate, turning the arm and stretching the springs. In this way, the sudden change in $\triangle cB'r$ is absorbed by the rotation of the spider shaft. The increased pressure exerted by the stretched springs returns the spider slowly to its original position, changing the differential output to the new speed or direction. When the springs have returned the arm to its original position, the differential output again matches the input. The magnetic drag geared to the spider shaft damps or slows the spring action, eliminating any tendency of the arm and spider to oscillate.

A large part of the inertia of the $\triangle cB'r$ output line is provided by a heavy magnetic damper.



THE TIME LINE

The mechanisms on the Time line are the Time Motor, the Time Motor Regulator, the Time Motor Switch, the Time Crank, and the Time Dials.

When the Computer is being operated, the Time line is always driven by the Time Motor, which is controlled by the Time Motor Regulator.

The Time line is turned by hand only when it is necessary to zero the Time Dials and to bring the Time line up to speed during certain tests.

The Time Dials

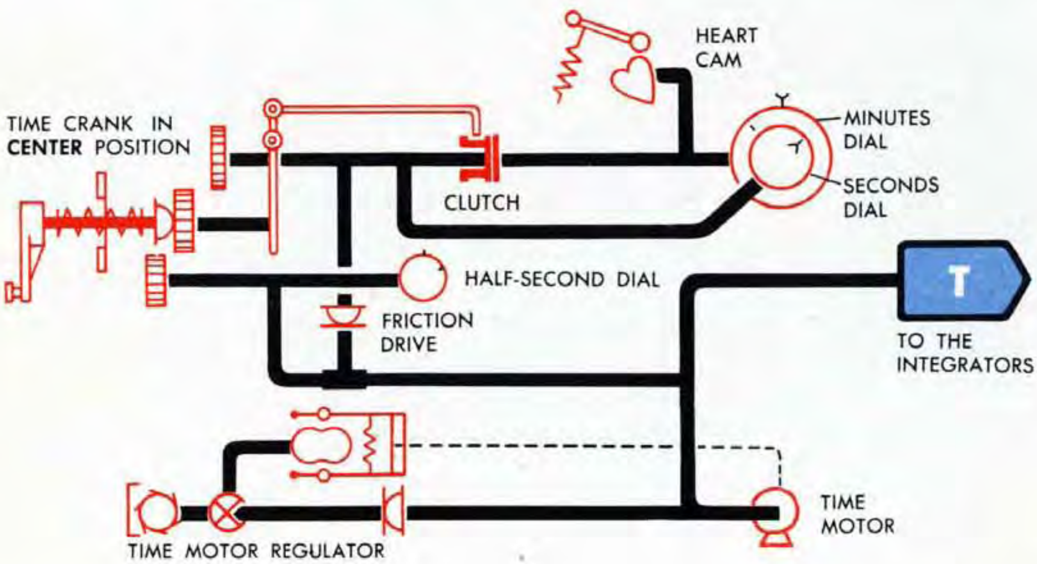
There are three Time Dials: a ring dial graduated in minutes, an inner dial graduated in seconds, and a small half-second dial with one graduation

The Time Crank

The Time Crank has three positions: CENTER, IN, and OUT. Centering springs keep the Time Crank in the CENTER position unless it is held in the IN or OUT position.

NORMAL OPERATION

When the Time Switch is turned ON and the Power Switch is ON, the Time Motor is energized and drives the Time line. The Time Crank is in CENTER position and is disengaged from the shaft line. Since Time, *T*, represents actual elapsed time by the clock, the Time Motor must be kept running at a definite constant speed under varying loads. This regulation is done by the Time Motor Regulator.



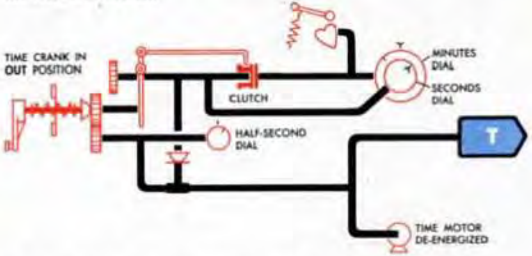
OPERATION DURING TESTS

The Time Crank is used to position all the Time Dials at zero before starting certain tests. The crank is also used at the start of each of these tests to bring the Time line up to speed.

This use of the Time Crank is described in detail in the chapter on B Tests in OP 1064A.

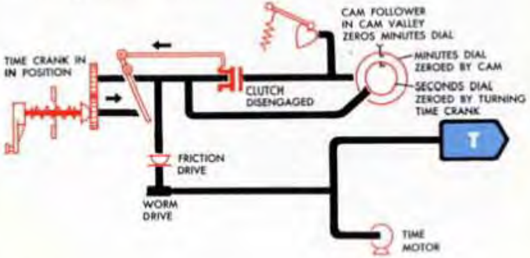
Zeroing the Time Dials

The Time Crank is first pulled OUT and turned clockwise to zero the Half-second Dial. In the OUT position, the crank is connected to the Time line and the entire line is turned to zero the Half-second Dial.



The Time Crank is then pushed to the IN position and turned to zero the Seconds Dial. Pushing the crank IN operates a clutch which disengages the Minutes Dial from the Time line. This allows the Minutes Dial to be returned to the zero position by a heart cam.

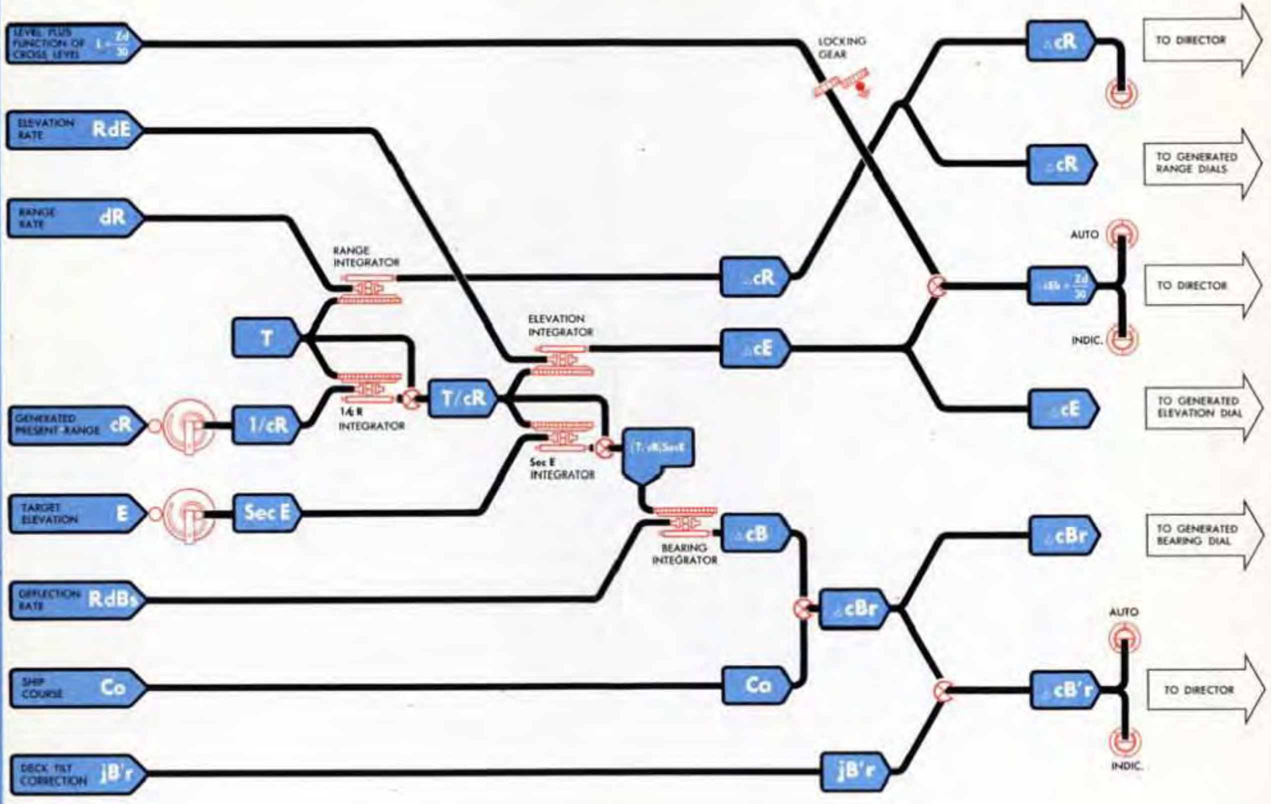
A friction drive on the line allows the Time Crank to be turned in the IN position to zero the Seconds Dial without disturbing the setting of the Half-second Dial.



COMPUTER MK 1, MOD 7

THE INTEGRATOR GROUP

SCHEMATIC DIAGRAM



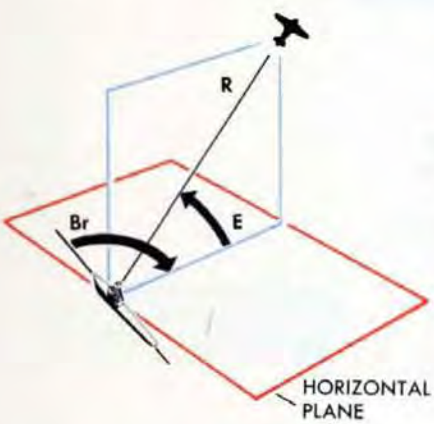
RATE CONTROL

The purpose of Rate Control is to correct the three Relative Motion Rates: *dR, RdE,* and *RdBs.*

All the necessary information for computing these three rates is available from the moment the Target is picked up, with the exception of accurate information about the speed and direction of Target Motion.

Information about the speed and direction of Own Ship Motion is always available and the position of the Target in relation to Own Ship is continuously measured from the moment the Target is picked up, but the speed and direction of the Target must first be estimated and then corrected. The process of correcting these estimates of Target speed and direction and thus correcting the Relative Motion Rates is called *"Rate Control."*

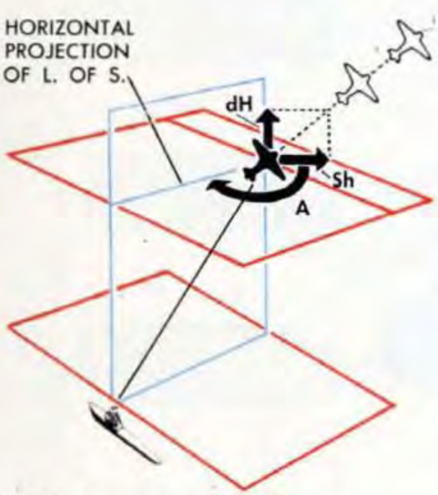
TARGET POSITION INPUTS TO THE RATE CONTROL MECHANISM



Information about the target

Target position

Information about the POSITION of the Target in relation to Own Ship is available whenever the Director sights are on Target. The Director continuously measures the Target Position in Range, *R,* Elevation, *Eb,* and Train, *B'r.* This information is continuously transmitted to the Computer. In the Computer, *Eb* and *B'r* are referred to the horizontal plane. Level, *L,* is subtracted from *Eb* to give *E,* in the Synchronize Elevation Mechanism. The Deck Tilt Correction, *jB'r,* is added to *B'r* to give *Br. R, E,* and *Br* are the Target Position inputs to the Rate Control Mechanism.



TARGET MOTION ESTIMATES

Target motion

The Director has no means of measuring the speed and direction of Target Motion directly. The values of Target Horizontal Speed, *Sh,* Rate of Climb, *dH,* and Target Angle, *A,* must be estimated first and corrected later by Rate Control. The initial estimates of Target Speed, Target Angle, and Rate of Climb may be called the Target Motion estimates.

The accuracy of the Target Motion estimates depends on the ability of the person doing the estimating. No matter how experienced he is, it is almost impossible for him to estimate *Sh, dH* and *A* with sufficient accuracy. These estimates must be checked and corrected.

Checking target motion estimates

Comparing observed and generated changes of target position

To check the Target Motion estimates, the Computer generates changes of Target Position on the basis of these Target Motion estimates. The *generated changes* are then compared with *observed changes* of Target Position. Using inputs of Own Ship Motion, Observed Target Position, and Estimated Target Motion, the Computer Mark 1 continuously generates changes of Range, Elevation, and Bearing. If these *Generated* Changes of Target Position go ahead of or fall behind the *Observed* Changes of Target Position, the estimated Target Motion values are wrong, since all the other inputs used are known to be correct.

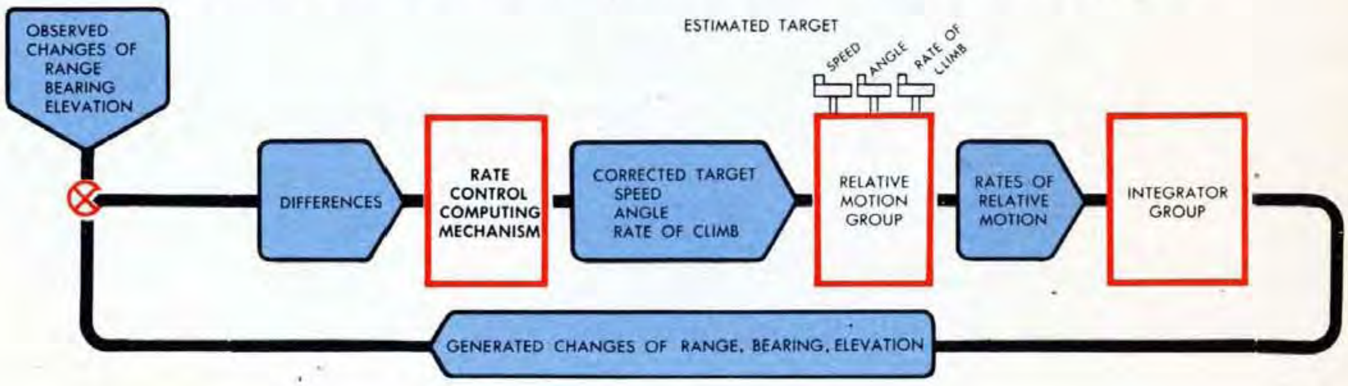
Correcting target motion estimates

The process of Rate Control consists in using the differences between the Generated and Observed Changes of Target Position to make corrections to Target Speed, Target Angle, and Rate of Climb.

These differences, or errors, are used as inputs to the Rate Control Computing Mechanism, which resolves them into corrections to the estimated values of Target Speed, Target Angle, and Rate of Climb. The corrected values of Target Speed, Target Angle, and Rate of Climb reposition the Relative Motion Component Solvers. The Component Solvers then compute more accurate Relative Motion Rates. These Relative Motion Rates are used to generate new changes of Target Position, which are again compared with the observed changes. When the Generated Changes vary in synchronism with the Observed Changes, the Relative Motion Rates are correct and will compute accurate predictions.

The term *"Rate Control"* is used in this OP to include all the methods of correcting the initial estimates of Target Speed, Target Angle and Rate of Climb, whether by the Rate Control Computing Mechanism, by direct hand alteration of the Target Motion inputs, or by a combination of the two.

This simplified schematic summarizes Rate Control through the Rate Control Computing Mechanism

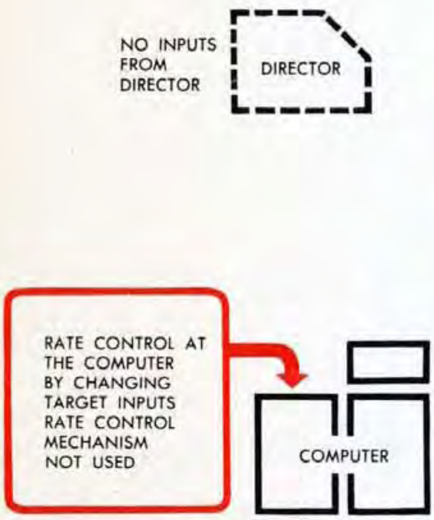


The FOUR MAIN METHODS of RATE CONTROL

Rate Control can be done in four distinct ways, or in combinations of these ways. These four main methods of Rate Control will be described in the order in which they are easiest to understand, beginning with the simplest method. This order is not intended to suggest any operating procedure.

Two methods DO NOT USE the rate control mechanism

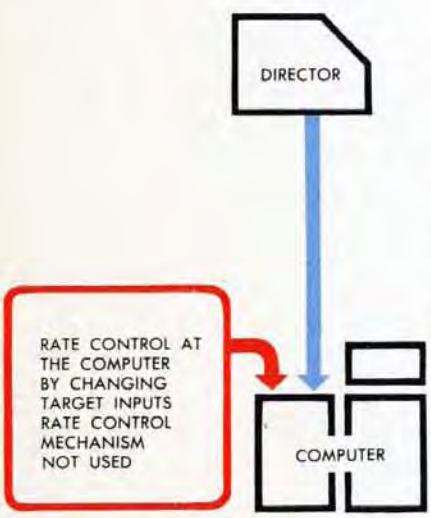
LOCAL CONTROL



FOR SURFACE TARGETS ONLY

LOCAL CONTROL may be thought of as an auxiliary form of Rate Control for surface firing. It consists of estimated hand corrections of Target Speed and Target Angle, based on intermittent reports of the Target's position. No Director inputs are received. The Computer Control Switch is at LOCAL. The Elevation input is hand-set at zero. Generated Range and Generated Bearing position all the Range and Bearing lines. Observed Range and Bearing are obtained and phoned to the plotting room. The Computer Operators compare the readings of the Range and Bearing Dials with the observed values received by phone. When the generated values begin to differ from the observed values, the Computer Operators estimate how much to correct Target Angle and Target Speed. They put these corrections into the Computer by turning the Target Speed and Target Angle Handcranks. They must also change the generated values of Range and Bearing to make them agree with the observed values received by phone.

MANUAL RATE CONTROL



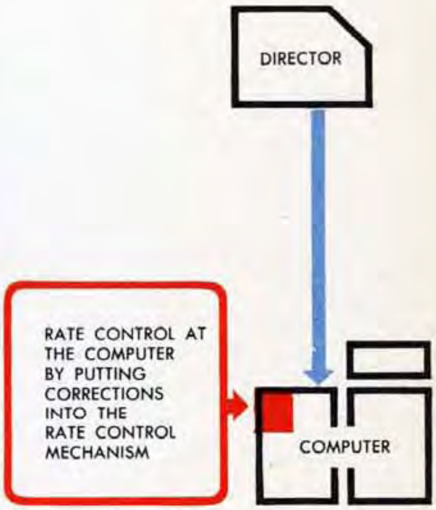
TARGET POSITION VALUES TRANSMITTED FROM DIRECTOR TO COMPUTER

MANUAL RATE CONTROL also consists of direct estimated hand corrections of Target Motion values, but instead of being based on intermittent reports, these corrections are made with the aid of dial movements which represent continuous observation of the Target from the Director. The Computer Control Switch is at SEMI-AUTO. Observed Range, Elevation, and Bearing are received electrically from the Director. Generated values of Range, Elevation, and Bearing come from the Integrator Group in the Computer. By comparing the dials which show Observed Changes, with the dials which show Generated Changes, the Computer Operators estimate how much to correct Target Speed, Target Angle, and Rate of Climb. They put these corrections into the Computer by turning the Target Speed, Target Angle, and Rate of Climb Handcranks. When the dials driven by the Generated Changes turn together with the dials driven by the Observed Changes, the Computer Operators know that the Target Motion inputs are correct.

Two methods USE the rate control mechanism

In SEMI-AUTOMATIC RATE CONTROL, the Rate Control Computing Mechanism does the work which in Manual Rate Control is done mentally by the operators. When the Generated Dials move out of synchronism with the Observed Dials, the Computer Operators put in Rate Corrections through the Generated Range, Generated Elevation and Generated Bearing Cranks. The Rate Control Computing Mechanism takes these Rate Corrections and translates them into corrections to Target Speed, Target Angle, and Rate of Climb. The Rate Control Computing Mechanism does most of the thinking necessary to correct the Target Motion estimates, and usually does it much faster and more accurately than the operators could. To summarize: The operators notice that the Generated Dials are moving either faster or slower than the Observed Dials. They make up this difference in rates of rotation by turning cranks which introduce Rate Corrections into the Rate Control Computing Mechanism. This mechanism then analyzes the three Rate Corrections. It determines what errors in *Sh*, *dH*, and *A* were responsible for the difference in rotation between the Generated and Observed Dials, and corrects these three Target Motion values.

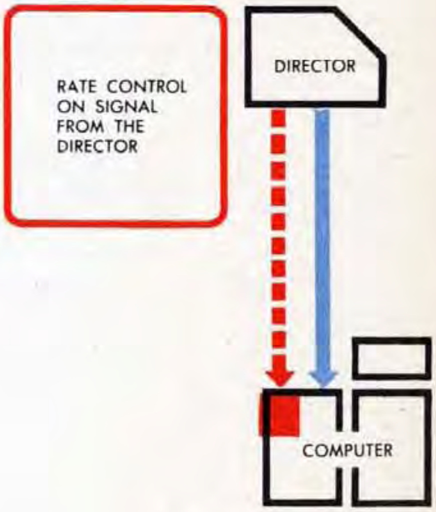
SEMI-AUTO
RATE CONTROL



TARGET POSITION VALUES TRANSMITTED FROM DIRECTOR TO COMPUTER

In AUTOMATIC RATE CONTROL, as in Semi-automatic Rate Control, the Rate Control Computing Mechanism is used. But in Automatic, the matching of the Generated Changes with the Observed Changes is controlled from the Director by the Pointer, Trainer, and Range Operator instead of the Computer Crew. In full Automatic Rate Control, the Computer Operators have little to do. They watch the dials as the problem develops and see that everything goes smoothly.

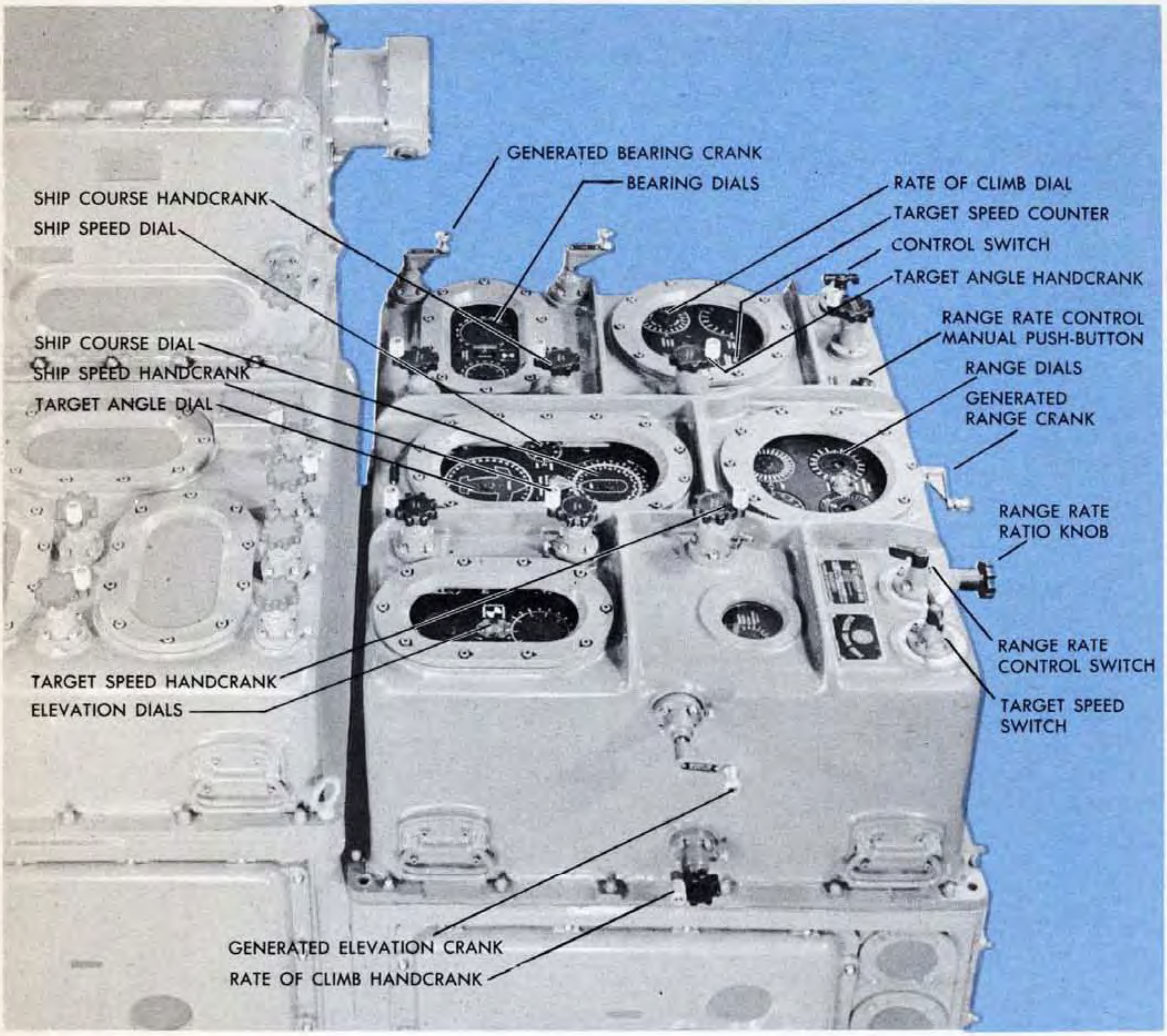
AUTO
RATE CONTROL



TARGET POSITION VALUES TRANSMITTED FROM DIRECTOR TO COMPUTER

Semi-automatic and Automatic Rate Control may be combined. For example, Elevation and Bearing could be in Automatic Control with Range in Semi-automatic Control.

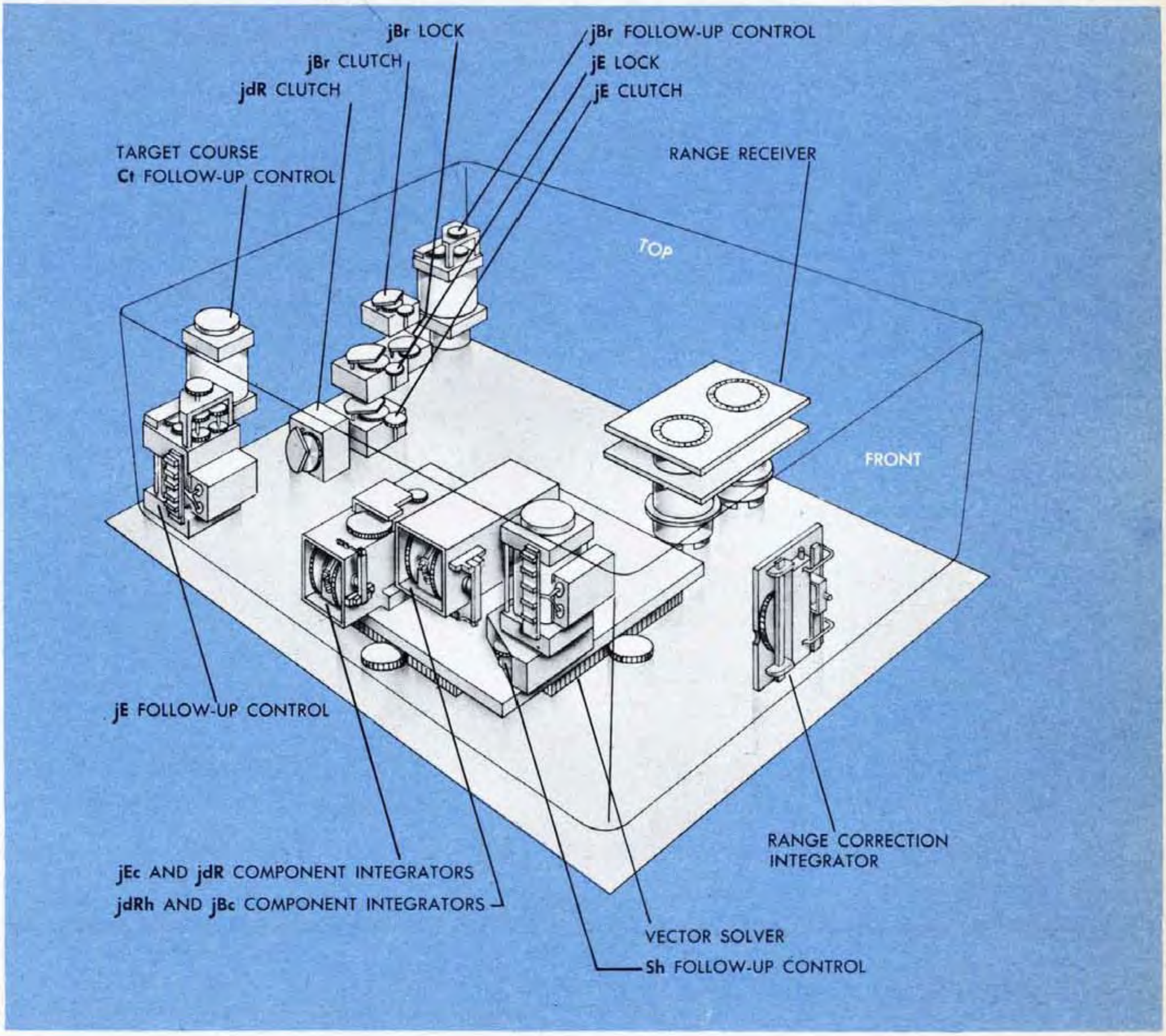
HANDCRANKS and DIALS used in RATE CONTROL



The dials, handcranks, and switches used in the various kinds of Rate Control are all mounted on the top front section of the Computer Mark 1.

In addition to these controls, the Rate Control Group contains the Range Receiver and the Rate Control Computing Mechanism.

The RATE CONTROL COMPUTING MECHANISM



The Rate Control Computing Mechanism is used in Automatic and Semi-automatic Rate Control. It consists mainly of:

- 4 Component Integrators
- 1 Vector Solver
- 1 4-inch Disk Integrator (Range Correction Integrator)
- 5 Follow-up Controls
- 3 Clutches
- 2 Locks

LOCAL CONTROL

Local Control is the direct hand correction of Target Speed and Target Angle on the basis of reports of Range and Relative Target Bearing from some source other than the Director. In most respects it is the simplest type of Rate Control, and for this reason it is described first.

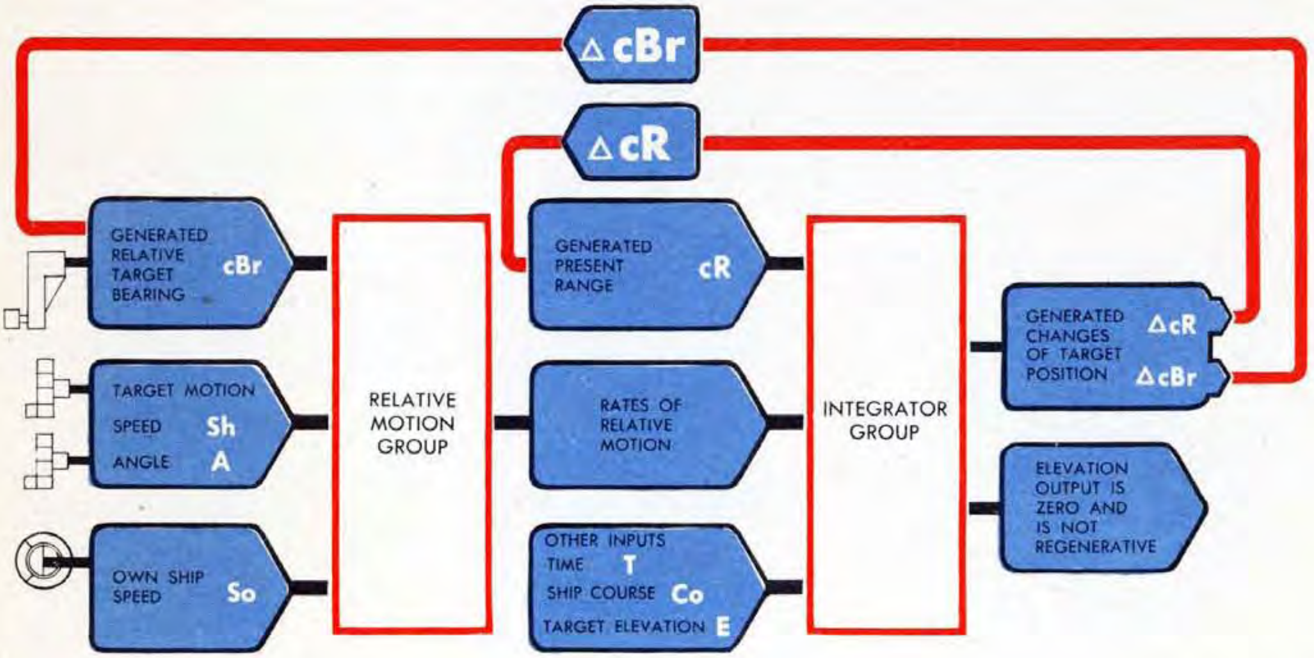
Used for surface targets only

In Local Control there are no Director inputs. Surface targets, which have no Rate of Climb, are the only moving targets for which the Computer Mark 1 is equipped to compute continuous Gun Orders *without the aid of Director inputs.* Operating in Local Control without the Director, the Computer keeps the Range and the Bearing. Generated Range and Generated Bearing continuously position all the Range and Bearing lines and dials. Elevation and Rate of Climb are hand-set at zero. The Elevation and Rate of Climb Dials remain at zero.

Target motion corrections are made by HAND

The values of Range and Relative Target Bearing generated by the Computer are compared by the Computer Crew with values received by phone. When the Generated Changes do not equal the Observed Changes, the inputs of Target Speed, *Sh,* and Target Angle, *A,* are corrected by hand with the *Sh* and *A* Handcranks.

This Schematic shows "Regeneration" in Local Control



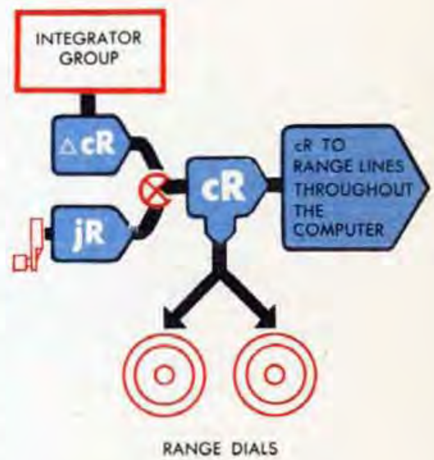
Range

When a Target is sighted, Observed Range, *R*, is phoned down to the Plotting Room and is put into the Computer through the Generated Range Crank in its OUT position. The hand input of Range is called *jR*.

The Generated Range line is then continuously positioned by the Generated Changes of Range, △*cR*, from the Integrator Group, giving a continuous value of Generated Range, *cR*.

Each time a value of Observed Range, *R*, is received by phone, it is compared with the generated value on the Range Dials. If the generated value is wrong, two kinds of corrections are made:

1. With the Generated Range Crank, a correction, *jR*, is put in to match Generated Range, *cR*, to Observed Range, *R*.
2. With the Target Speed and Target Angle Handcranks, corrections are made to *Sh* and *A*. These corrections go to the Relative Motion Group, where the Range Rate, *dR*, is corrected. The corrected *dR* is then used in generating Changes of Range, △*cR*, at a corrected rate. When *Sh* and *A* are correct, △*cR* will keep Generated Range, *cR*, equal to Observed Range, *R*.

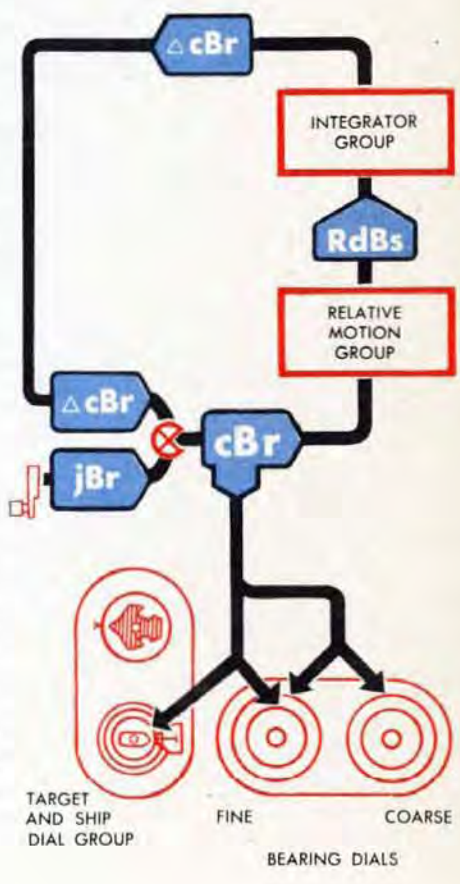


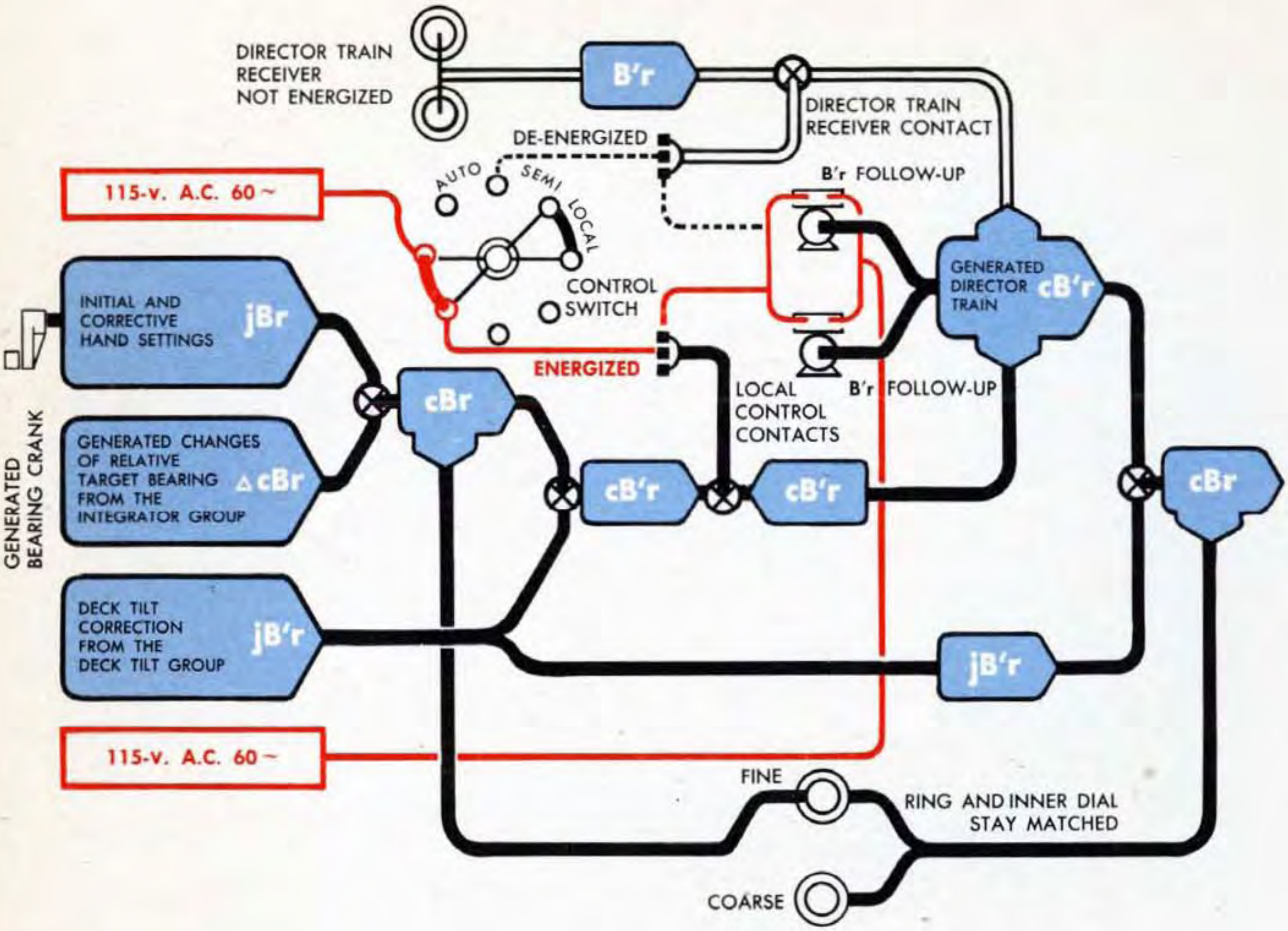
Bearing

Relative Target Bearing, *Br*, is phoned down from the observation station on deck and put into the Computer through the Generated Bearing Crank. After the initial Observed Bearing input, corrections to Generated Bearing called *jBr* are put into the Computer through the same Generated Bearing Crank. In the Computer, *jBr* is added to the Generated Changes of Relative Target Bearing, △*cBr*, from the Integrator Group, giving corrected Generated Bearing, *cBr*. Generated Bearing, *cBr*, positions all the Bearing Dials.

Each time a value of Observed Relative Bearing is phoned down, it is compared with the *generated* value on the Bearing Dials. If the generated value is wrong, the Computer Crew makes two kinds of corrections:

1. With the Generated Bearing Crank, a correction, *jBr*, is set in to make the reading on the Bearing Dials equal to the observed value of *Br*.
2. Corrections to *Sh* and *A* are put in with the Target Speed and Target Angle Handcranks. The corrected values of *Sh* and *A* in the Relative Motion Group then correct the Bearing Rate, *RdBs*, used in Generated Changes of Bearing, △*cBr*. When *Sh* and *A* are correct, the Generated Changes of Bearing, △*cBr*, will keep Generated Bearing equal to Observed Bearing.





This is a combined wiring diagram and schematic, showing the flow of quantities and the electrical circuits energized on the Bearing line *when the Control Switch is at LOCAL.*

This drawing also shows how, in Local Control, the Generated Bearing Crank and the Changes of Generated Relative Target Bearing from the Integrator Group position the Observed Relative Target Bearing line.

The *B'r* line is always positioned by two servo motors. In Local Control, both servos are controlled by the Local Control Contacts.

SOLVING A TRACKING PROBLEM IN LOCAL CONTROL

Here is a simple tracking problem which illustrates the general principles of Rate Control:

Assume that Own Ship is motionless.
The Control Switch is set at LOCAL.

The following information is phoned to the Computer Operators:

A Target has been observed at 9000 yards Range, moving away from Own Ship.

Observed Relative Target Bearing, *Br*, is 75 degrees.

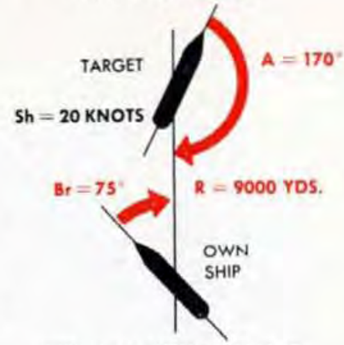
Target Angle, *A*, is estimated at 170 degrees.

Target Speed, *Sh*, is estimated at 20 knots.

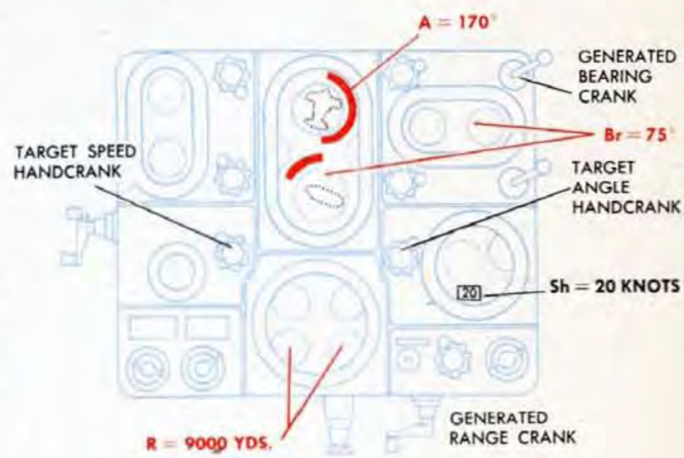
These values are set into the Computer by turning the Generated Range and Bearing Cranks, and the Target Speed and Target Angle Handcranks.

The Time Switch is turned ON and the Computer begins to generate Range and Bearing.

TARGET ESTIMATES



INITIAL OBSERVED RANGE AND BEARING



Comparing generated with observed range and bearing

About one minute after the initial inputs to the Computer are made, values of *R* and *Br* are received by the Computer Operators:

Observed Present Range, *R* = 10,000 yards

Relative Target Bearing, *Br* = 75 degrees.

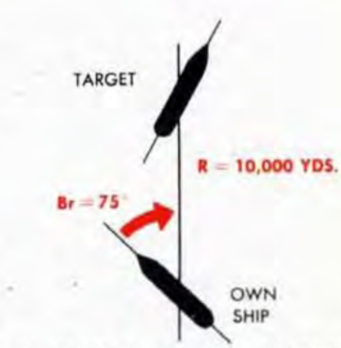
A quick reading of Range and Bearing generated by the Computer shows that:

Generated Present Range, *cR* = 9725 yards

Generated Relative Target Bearing, *cBr* = 75°40′.

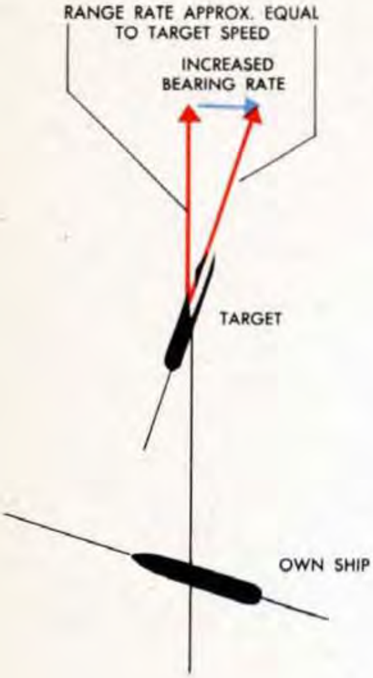
A comparison of the observed and generated values shows that during the elapsed time of one minute, *cR* increased 275 yards less than *R*, and *cBr* increased 40 minutes more than *Br*.

Since *cR* became less than *R* but *cBr* became greater than *Br*, the comparison suggests that Range Rate must be increased and Bearing Rate decreased.



OBSERVED RANGE AND BEARING AFTER ONE MINUTE

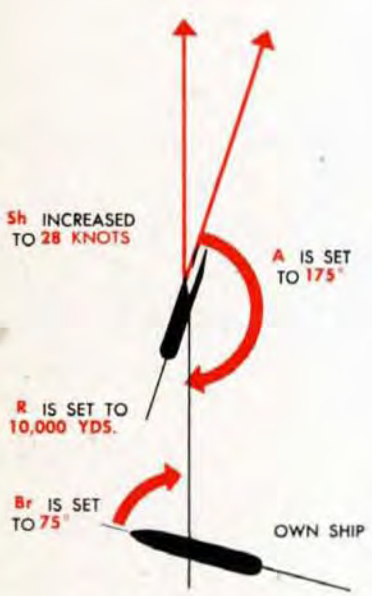
GENERATED RANGE AND BEARING AFTER ONE MINUTE



Determining which quantities to correct

The direction of the Target Motion with respect to the Line of Sight makes it evident that any increase in Target Speed will cause an increase in Range Rate. This increase in Target Speed will also cause an increase in Bearing Rate, which is not desired in this case. The Bearing Rate can be decreased by increasing Target Angle.

The Computer Operators decide to increase Target Speed and Target Angle, but the sizes of these corrections must still be determined.



CORRECTED SETUP

Determining the size of the corrections

Comparison of Observed and Generated Range and Observed and Generated Bearing indicates that the Range Rate is more in error than the Bearing Rate.

The estimated direction of Target Motion relative to the Line of Sight is such that a change in Target Speed will cause an approximately corresponding change in Range Rate and will affect Bearing Rate only slightly.

The difference between observed and generated values of Range was 275 yards in 1 minute. Since one knot of Range Rate causes a Range change of 33.78 yards per minute, the Computer Operators decide to increase Target Speed by 8 knots. To compensate for the increase that this *Sh* change will cause in the Bearing Rate, Target Angle is increased to 175 degrees.

The Operators reset the Computer to the *observed* values:

Observed Present Range, *R*, to 10,000 yards
Relative Target Bearing, *Br*, to 75 degrees

They also correct the Target Motion estimates:

Target Speed, *Sh*, is changed to 28 knots
Target Angle, *A*, is changed to 175 degrees

NOTE:
Because the dials were read while in motion, the values will not necessarily agree with precise computations.

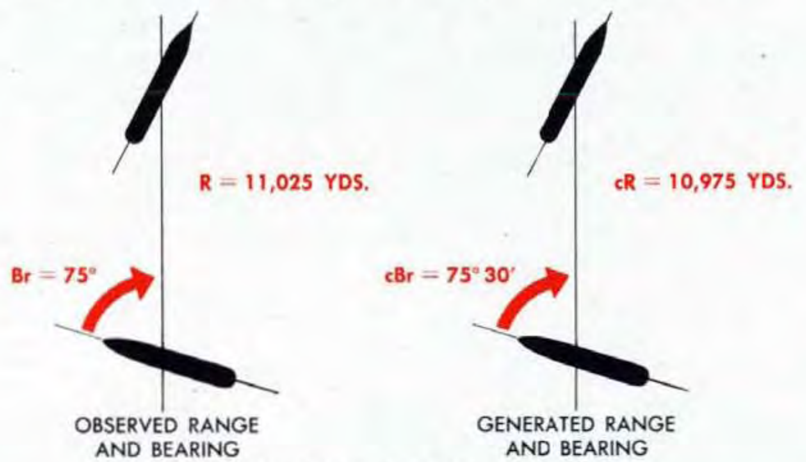
Completing the problem

At the end of the second minute, the Computer Operators receive these *observed* values:

Observed Present Range, $R = 11{,}025$ yards
Relative Target Bearing, $Br = 75$ degrees

The Computer readings are now:

Generated Present Range, $cR = 10{,}975$ yards
Generated Relative Target Bearing, $cBr = 75°30'$



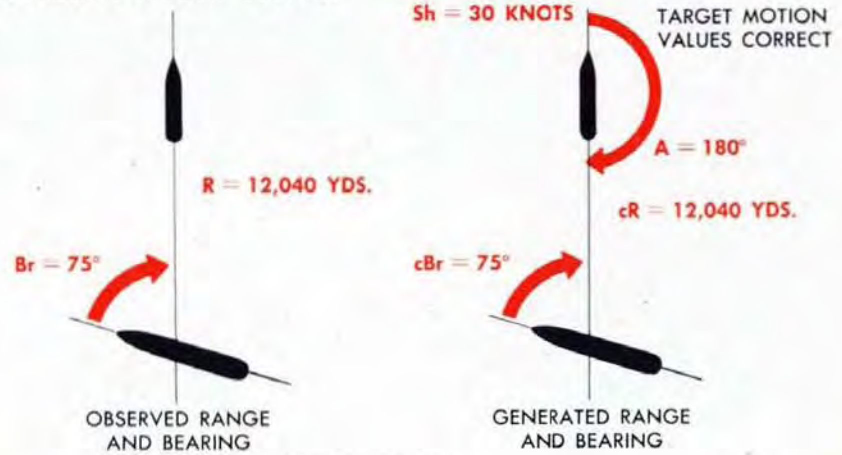
AFTER TWO MINUTES

A comparison of the Observed and Generated Range and Bearing values now shows that there is very little error.

Using the same reasoning as for the first set of corrections, these further corrections are made:

Target Speed is changed to 30 knots
Target Angle is changed to 180 degrees

After these corrections are made, and the Computer is reset to the observed values, the Computer generates a value of Genrated Present Range, *cR*, which is equal to Observed Present Range, *R*, and a value of Generated Relative Target Bearing, *cBr*, which is equal to Relative Target Bearing, *Br*. The Tracking Problem is now solved.



PROBLEM SOLVED

MANUAL CONTROL OF RATES

In Manual Control of rates, corrections to Target Speed and Target Angle and Rate of Climb are estimated by the Computer Crew with the aid of continuous Director observations of Target Position.

The Observed Changes of Target Position in relation to Own Ship in Range, Elevation, and Bearing are continuously sent from the Director to the Computer by synchro transmission. Observed Changes of Target Position show up on the Computer as rotation of three sets of dials: the outer Elevation Dials, the outer Bearing Dials, and the inner Range Dials. These are the *Observed Dials.*

Generated Changes of Target Position from the Integrator Group in the Computer turn the inner Elevation and Bearing Dials, and the outer Range Dials. These dials are the *Generated Dials.*

The Computer Crew watch the Observed and Generated Dials. They correct the values of *Sh, dH,* and *A* by hand at the *Sh, dH,* and *A* Handcranks until the Generated Dials turn in synchronism with the Observed Dials.

Manual rate control for surface and air targets

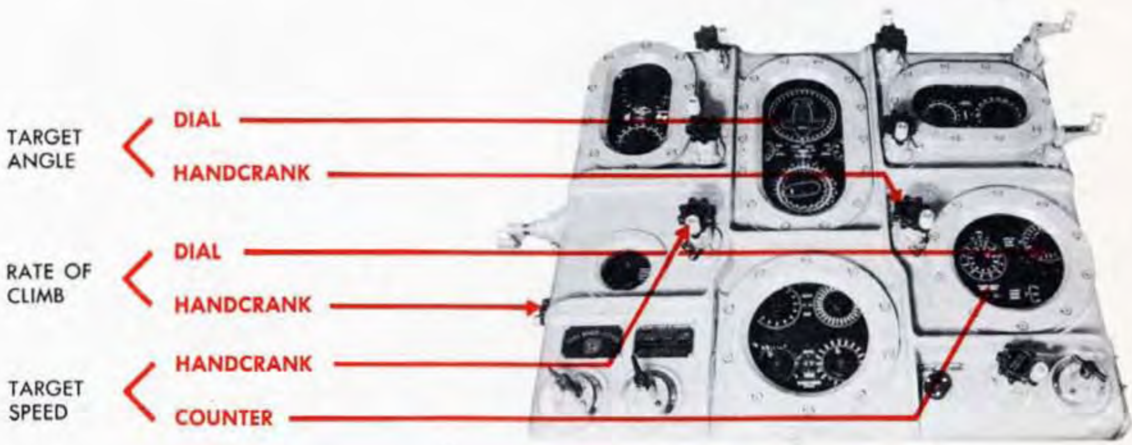
The Rate Control Computing Mechanism used in Automatic and Semi-automatic Rate Control is not designed to compute corrections to the Target Motion inputs when Target Speed is less than about 70 knots. For this reason, Local Control and Manual Rate Control are the only types of Rate Control which can be used against most surface targets.

Since Observed Elevation is continuously received in Manual Rate Control, Manual Rate Control may also be used against air targets. However, the short duration of air problems and the complexities of target movement in three dimensions make Manual Rate Control against air targets difficult. Manual Rate Control against air targets may be regarded as an auxiliary type of operation, while Manual Rate Control against surface targets is a normal type of operation.

Correcting the target motion quantities

To allow the Target Motion values to be corrected through the *Sh, dH,* and *A* Handcranks in Manual Rate Control, the Control Switch must be at SEMI-AUTO, and the Range Rate Control Switch at MANUAL. The circuits affected by these switches are described on pages 258-261. The levers on the Target Speed and Target Angle Handcranks must be in HAND position and the Rate of Climb Handcrank in its IN position, because these are the positions in which the handcranks are connected to the *Sh, dH,* and *A* shaft line.

Corrections are made to one or more of the Target Motion values, *Sh, dH,* and *A,* whenever any of the Generated Dials does not turn in synchronism with its corresponding Observed Dial.



The Computer Operators put in corrections to the Target Motion values until the corrected Relative Motion Rates cause the *generated* values of Range, Elevation, and Bearing to change at the same rates as the *observed* values of Range, Elevation, and Bearing are changing. Range dials must be matched.

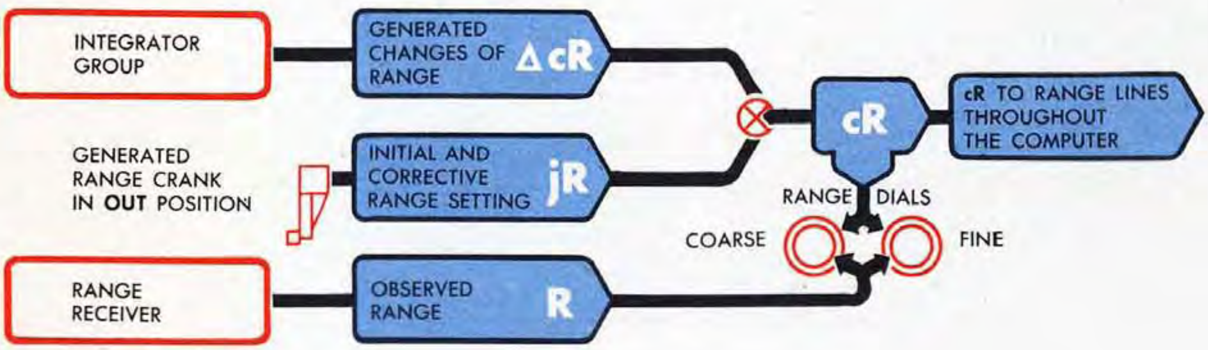
Information that will help the Operators determine which of the Target Motion quantities should be corrected is contained in the chapter on Operating Instructions, page 128.

How the dials receive observed and generated values

Range

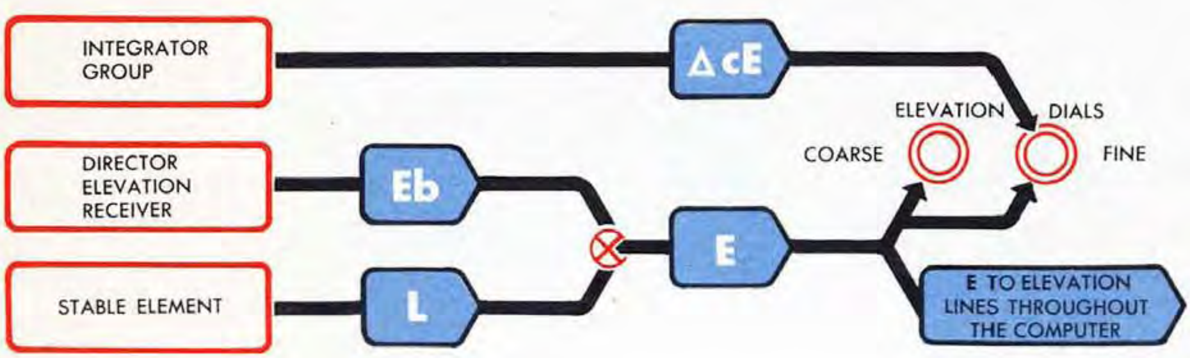
Observed Range is transmitted from the Director to the Range Receiver in the Computer. Observed Range positions the fine and coarse inner Range Dials. Generated Range, *cR*, positions all the other Range lines in the Computer, and the fine and and coarse outer Range Dials.

The reasons why *cR*, rather than *R*, is used to position the Range lines throughout the Computer have been mentioned in the General Description, page 54, and are explained in more detail on page 76.



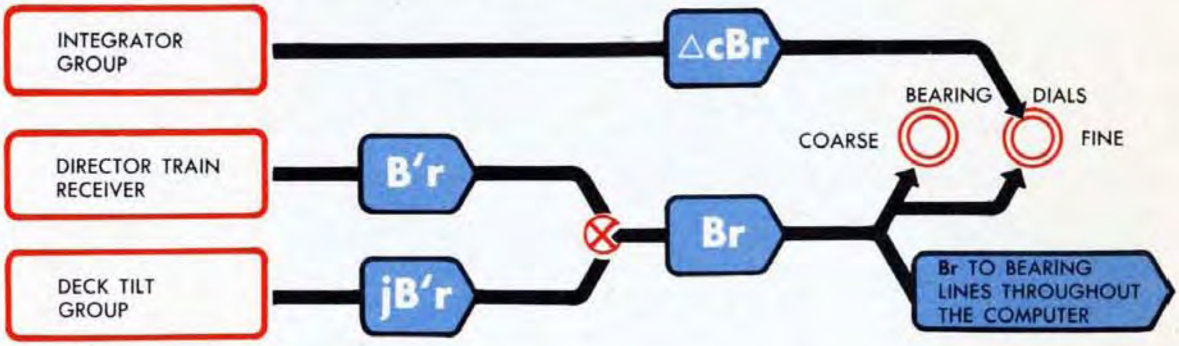
Elevation

Director Elevation, *Eb*, is continuously received by the Director Elevation Receiver. Level, *L*, is subtracted from *Eb* to obtain Target Elevation, *E*, which positions the fine and coarse Observed Elevation Dials. Generated Changes of Target Elevation, △*cE*, from the Integrator Group, turn the Generated Elevation Dial.

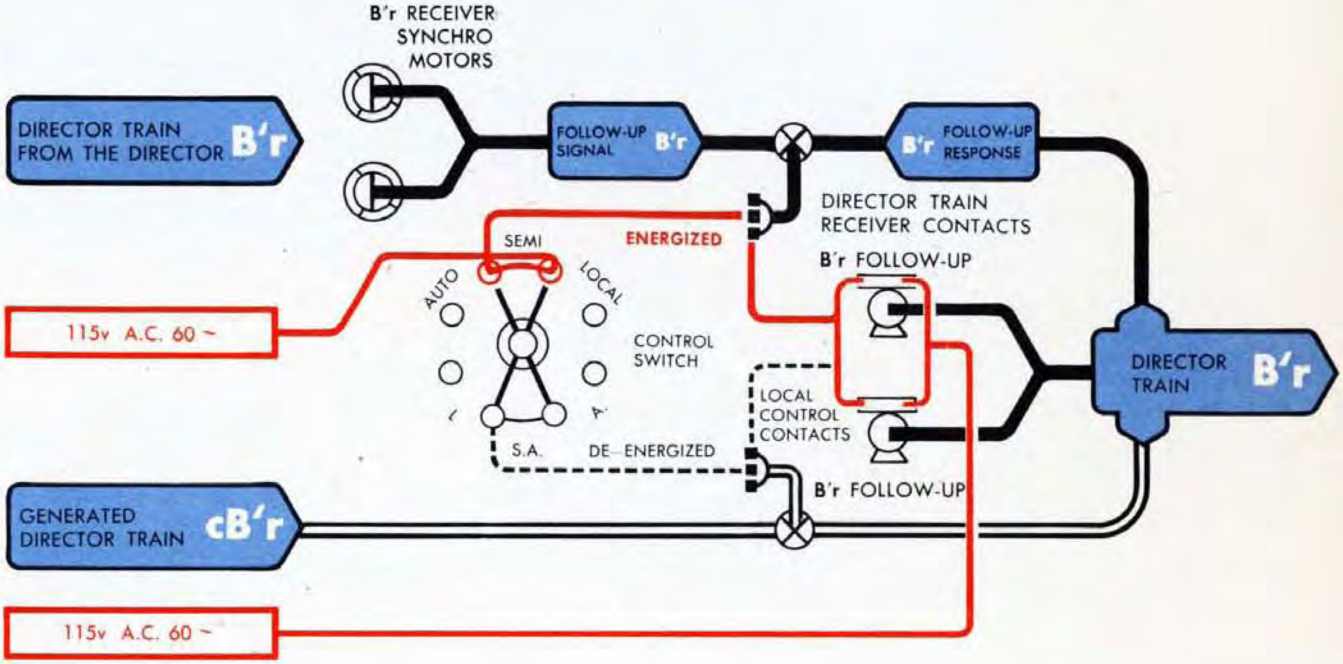


Bearing

In Manual Rate Control the Director transmits an input of Director Train, *B′r*, to the *B′r* Receiver in the Computer. Deck Tilt Correction, *jB′r*, is added to *B′r* to obtain Observed Relative Target Bearing, *Br*. *Br* positions all the Bearing lines in the Computer and the outer Bearing Dials, fine and coarse. Generated Changes of Relative Target Bearing, △*cBr*, from the Integrator Group, position the inner Bearing Dial. Generated Bearing does not regenerate in Manual Rate Control.



The diagram below shows the electric circuits energized in the Bearing network when the Control Switch is at SEMI-AUTO. Both *B′r* Servo Motors are now energized by the Director Train Receiver contacts. The contacts which were energized when the Control Switch was at LOCAL are now de-energized.



SEMI-AUTOMATIC RATE CONTROL

In Semi-automatic Rate Control, the Rate Control Computing Mechanism computes the necessary corrections to Target Speed, Target Angle, and Rate of Climb. Whenever the Computer Operators see that one or more of the Generated Dials are turning faster or slower than the corresponding Observed Dials, they put Rate Corrections into the Rate Control Computing Mechanism with the Generated Range, Generated Elevation, and Generated Bearing Cranks. These Rate Corrections are automatically converted into corrections to Target Motion values by the Rate Control Computing Mechanism.

The operators do not have to figure out what corrections to Sh, dH, and A are needed. They turn the Generated Cranks, thereby putting Rate Corrections into the Rate Control Computing Mechanism. The Rate Control Computing Mechanism automatically resolves these Rate Corrections into corrections to Sh, dH, and A.

If the Generated Range Dials begin to turn faster or slower than the Observed Range Dials, the Range Operator turns the Generated Range Crank to match the Range Dials, while depressing the Manual Range Push-button. By so doing, he also puts a Range Rate Correction, *jdR*, into the Rate Control Computing Mechanism.

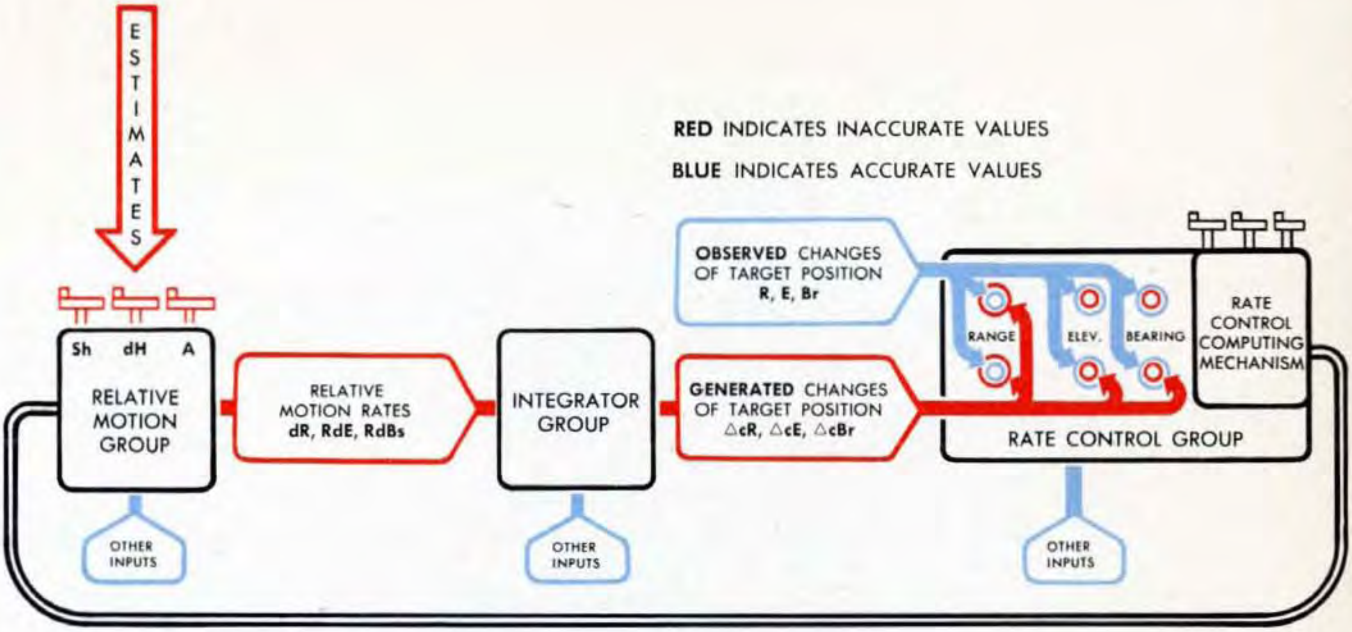
If the Generated Elevation Dial begins to turn faster or slower than the fine Observed Elevation Dial, the Elevation Operator uses the Generated Elevation Crank to put enough Elevation Rate Correction, *jEc*, into the Rate Control Computing Mechanism to make the Elevation Dials turn together.

In the same way, the Bearing Operator puts a Bearing Rate Correction, *jBc*, into the Rate Control Computing Mechanism to make the Bearing Dials turn together.

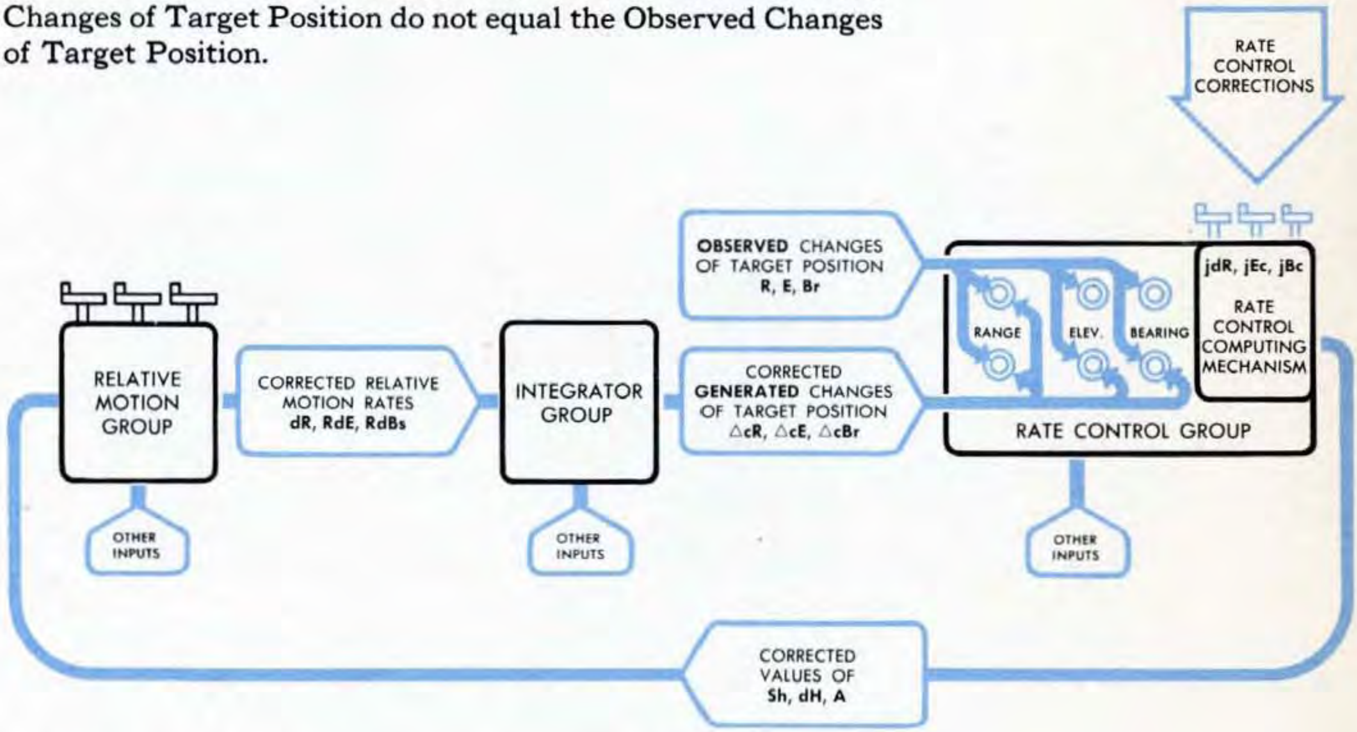
The Rate Control Computing Mechanism uses the three Rate Corrections, *jdR*, *jEc*, and *jBc* to compute a correction to *dH* and corrected values of *Sh* and *A*. These values are then transmitted mechanically to the Relative Motion Group.

The corrected values of *Sh*, *dH* and *A* cause the Relative Motion Group to compute corrected Relative Motion Rates. The corrected rates go to the Integrator Group and cause the changes of Range, Elevation, and Bearing to be generated at corrected rates.

After one or more sets of Rate Corrections have been put into the Rate Control Computing Mechanism, the Generated Dials will turn in synchronism with the Observed Dials, indicating that the Target Motion values and the Relative Motion Rates are correct. This is called a "solution."



This schematic shows the groups of quantities at the beginning of a fire control problem. The values of *Sh, dH* and *A*, are human estimates and therefore contain some error. The Generated Changes of Target Position do not equal the Observed Changes of Target Position.



This schematic shows the groups of quantities after the Operators have put Rate Corrections into the Rate Control Computing Mechanism. These corrections have been automatically converted into corrections to *Sh, dH*, and *A*. The corrected Target values have corrected the Relative Motion Rates which are now being used to generate changes of Range, Elevation and Bearing which keep the Generated Dials in synchronism with the Observed Dials.

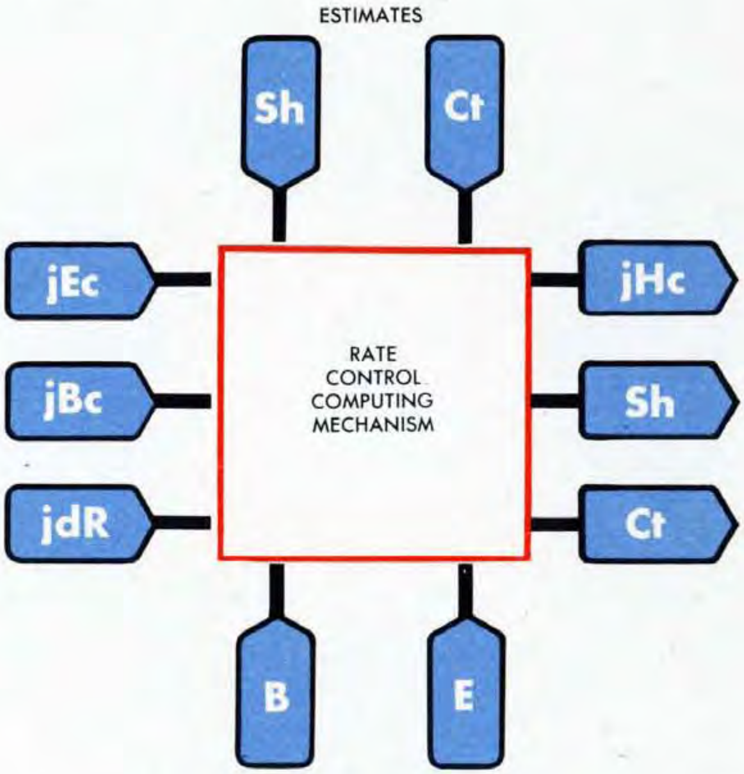
The RATE CONTROL COMPUTING MECHANISM

The Rate Control Computing Mechanism consists of these units:

Four component integrators, grouped in pairs
One vector solver
One four-inch disk integrator
Five follow-ups
Two solenoid locks and three solenoid clutches
Several differentials

There are seven *inputs* to the Rate Control Computing Mechanism:

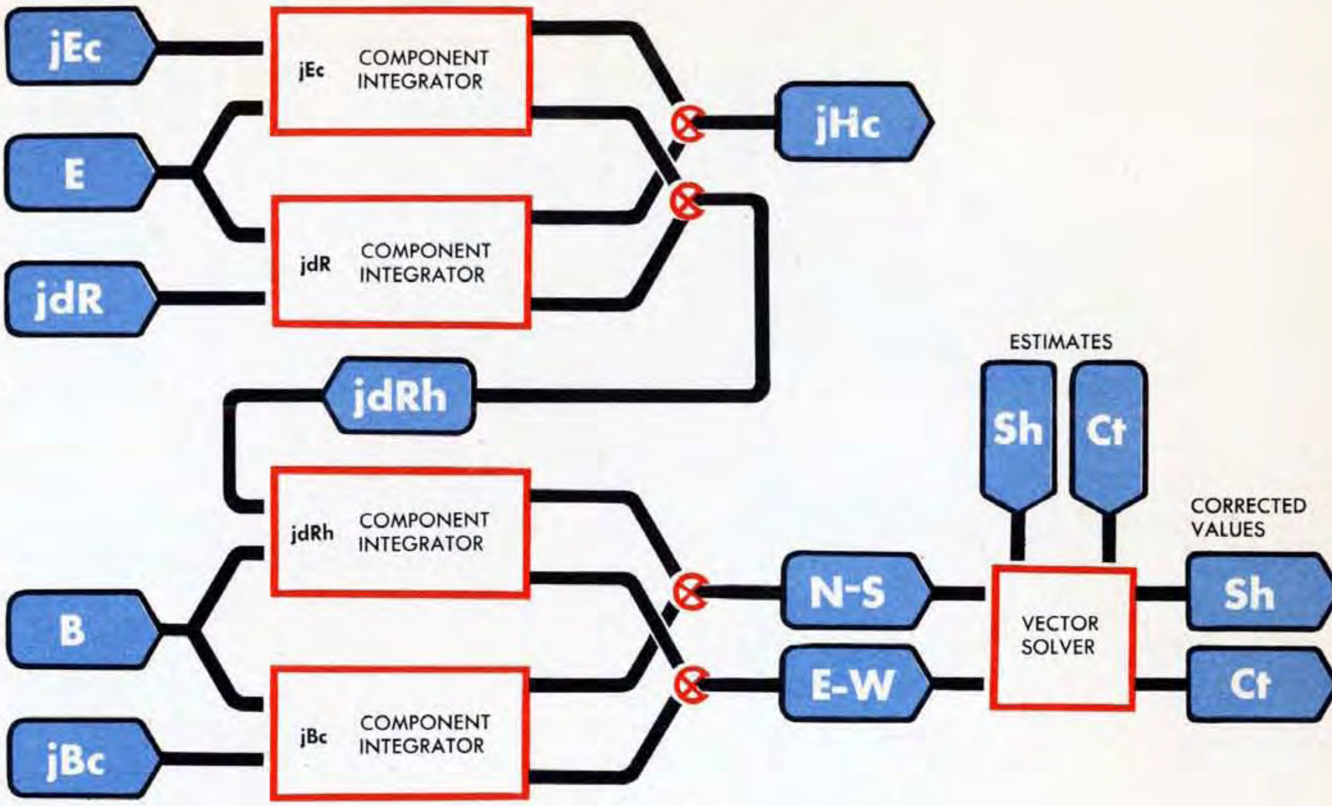
1. Linear Elevation Rate Correction, *jEc*
2. Linear Deflection Rate Correction, *jBc*
3. Direct Range Rate Correction, *jdR*
4. True Target Bearing, *B*
5. Observed Target Elevation, *E*
6. Horizontal Target Speed (estimated), *Sh*
7. Target Course (estimated), *Ct*



The *outputs* from the Rate Control Computing Mechanism are:

1. A Rate of Climb Correction, *jHc*, which is a correction to Rate of Climb, *dH*
2. A corrected value of Horizontal Target Speed, *Sh*
3. A corrected value of Target Course, *Ct*

How Sh, dH, and Ct are corrected



The three rate corrections, *jEc*, *jBc*, and *jdR* are used as inputs to three of the component integrators. Each component integrator has two outputs. These outputs are components of the inputs, at right angles to each other.

The outputs from the *jEc* and *jdR* Component Integrators are grouped to form two new values:

Rate of Climb Correction, *jHc*
Horizontal Range Rate Correction, *jdRh*

jHc is the required correction to Rate of Climb, *dH*.

jdRh becomes the input to the fourth component integrator.

The outputs of the *jdRh* and *jBc* Component Integrators are combined to obtain two values:

A North-South Correction to the Horizontal Target Speed Vector

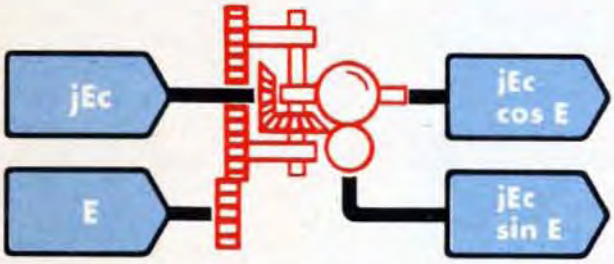
An East-West Correction to the Horizontal Target Speed Vector

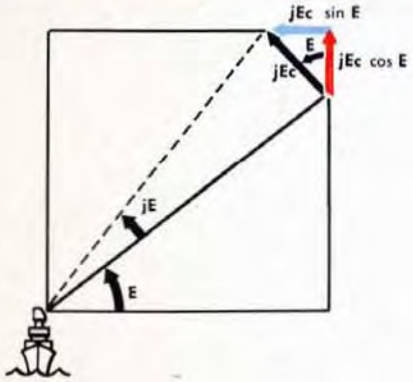
The Vector Solver is initially positioned by the estimated values of Horizontal Target Speed, *Sh*, and Target Course, *Ct*. The *N-S* and *E-W* Speed Corrections reposition the Vector Solver racks. Moving these racks corrects the previous Vector Solver values of *Sh* and *Ct*. The outputs of the Vector Solver are the *corrected* values of *Sh* and *Ct*.

The ELEVATION COMPONENT INTEGRATORS

The four component integrators work in pairs. The first pair of component integrators of the Rate Control Computing Mechanisms consists of the *jEc* and the *jdR* Component Integrators. They work together to produce horizontal and vertical rate corrections.

The jEc component integrator





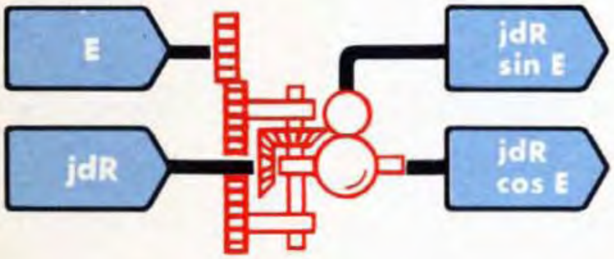
Elevation Rate Correction, *jEc,* is one input to the *jEc* Integrator. *jEc* turns the input roller. Target Elevation, *E,* is the other input. *E* positions the angular input gear.

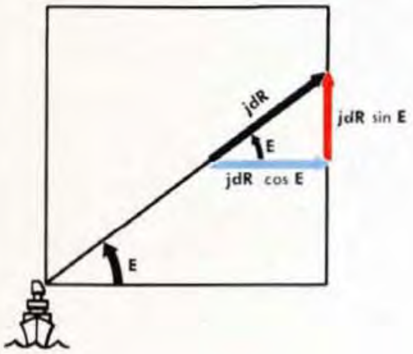
The *jEc* Component Integrator breaks *jEc* into vertical and horizontal components:

1 The vertical component is *jEc* cos *E*.

2 The horizontal component is *jEc* sin *E*.

The jdR component integrator





Direct Range Rate Correction, *jdR,* turns the input roller of the *jdR* Component Integrator. Target Elevation, *E,* positions the angular input gear.

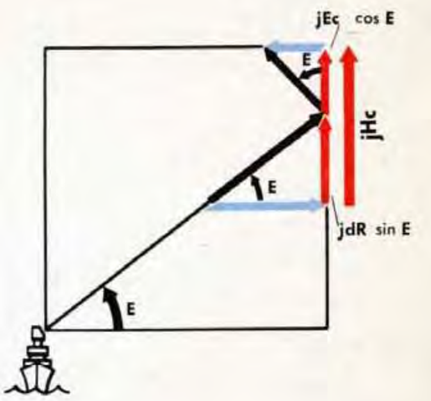
The *jdR* Component Integrator breaks *jdR* into vertical and horizontal components:

1 The vertical component is *jdR* sin *E*.

2 The horizontal component is *jdR* cos *E*.

The components of jEc and jdR are combined

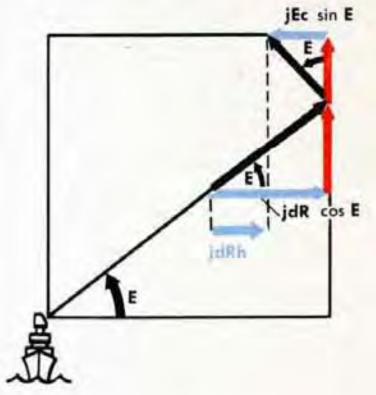
The *jEc* and *jdR* Component Integrators each produce one vertical and one horizontal component.



The two vertical components, one from each component integrator, are combined, giving *jHc*. Here the two vertical components are added because they are in the same direction.

$$jEc \cos E + jdR \sin E = jHc$$

jHc is a vertical correction, called the Rate of Climb Correction. jHc corrects dH by repositioning the dH lines.

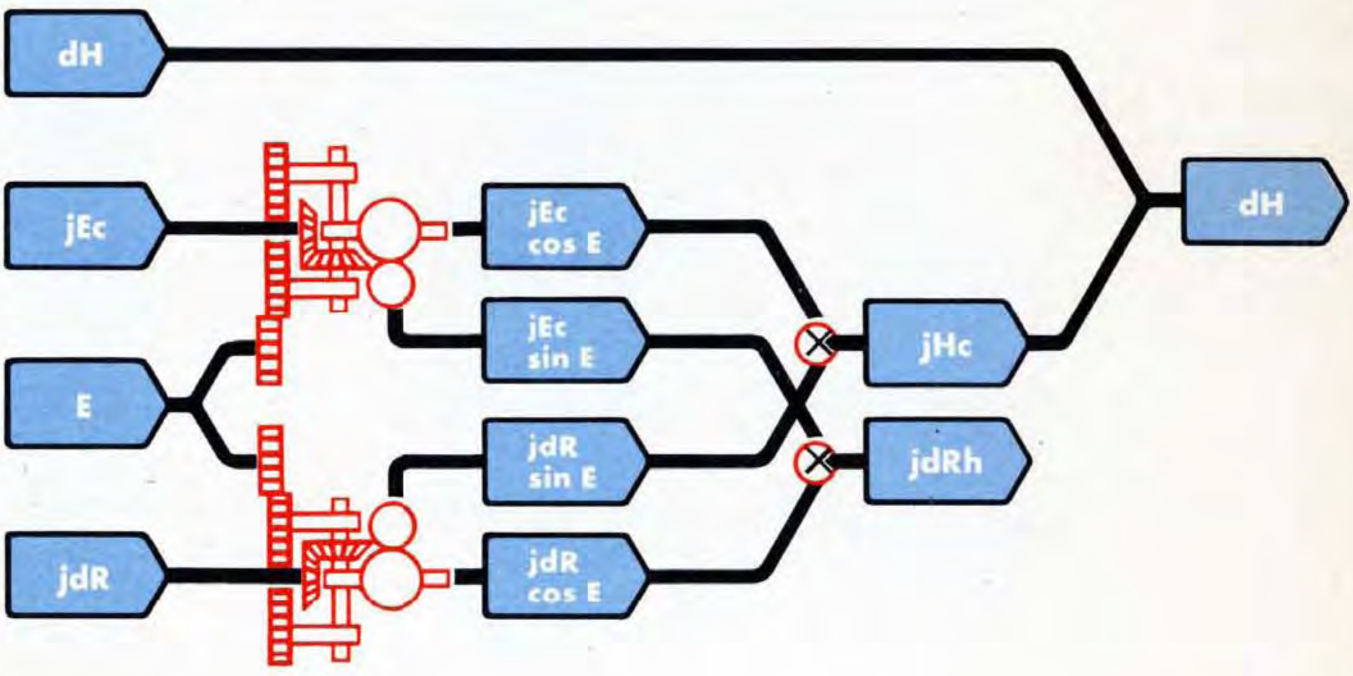


The two horizontal components, one from each component integrator, are combined, giving *jdRh*. In this example, one component is subtracted from the other because they are in opposite directions.

$$jdR \cos E - jEc \sin E = jdRh$$

jdRh is a horizontal correction in the plane containing the Line of Sight. It is not a correction to a Target value, but is used as an input to the jdRh Component Integrator. jdRh is called the Horizontal Range Rate Correction.

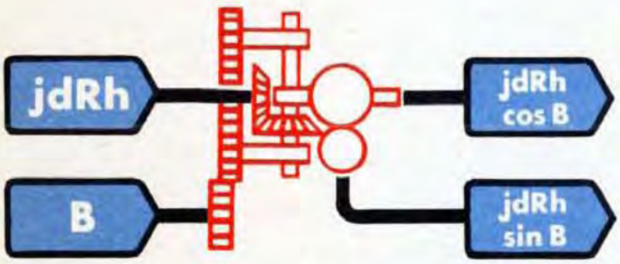
Remember that the job of the Rate Control Computing Mechanisms is to produce corrections to *Sh, dH,* and *Ct*. The first of these three corrections, *jHc*, is computed by the first pair of component integrators and is used to correct Rate of Climb, *dH*.

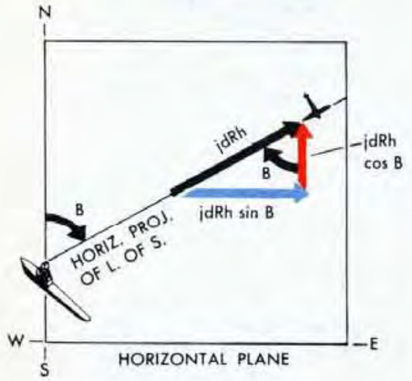


The BEARING COMPONENT INTEGRATORS

So far two corrections have been computed: the correction to *dH*, called *jHc*, and the Horizontal Range Rate Correction, *jdRh*.

A second pair of component integrators uses *jdRh* and the Deflection Rate Correction, *jBc*, to compute rate corrections along a North-South and East-West axis. These *N-S* and *E-W* Corrections are needed by the Vector Solver to compute corrections to Target Speed, *Sh*, and Target Course, *Ct*.





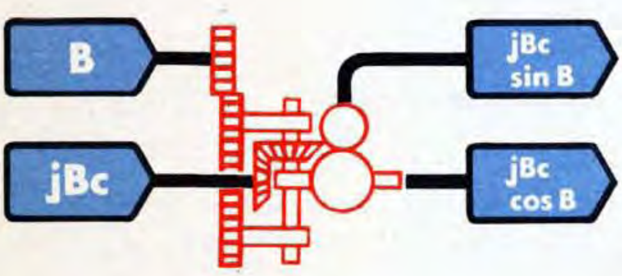
The jdRh component integrator

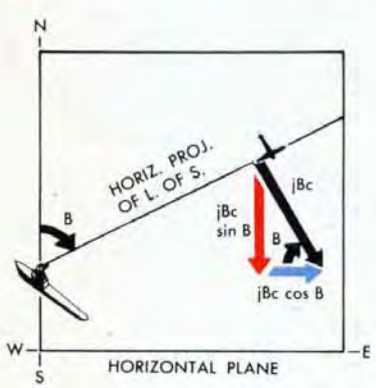
Direct Range Rate Correction, *jdRh*, and True Target Bearing, *B*, are the inputs to the *jdRh* Component Integrator. *B* is the angle between North and the horizontal projection of the Line of Sight measured in the horizontal plane. *jdRh* drives the input roller and *B* positions the angle input gear.

The outputs are two components at right angles to each other:

1 Along the *E-W* axis, *jdRh* sin *B*.

2 Along the *N-S* axis, *jdRh* cos *B*.





The jBc component integrator

Deflection Rate Correction, *jBc*, and True Target Bearing, *B*, are the inputs to the *jBc* Component Integrator. *jBc* drives the input roller and *B* positions the angle gear.

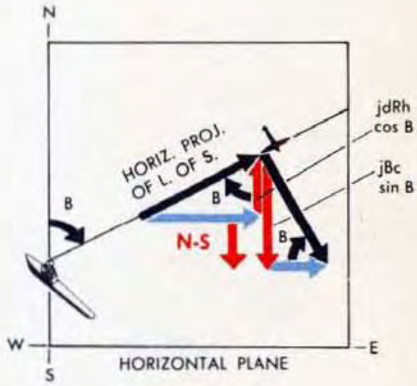
The outputs are two components at right angles to each other:

1 Along the *E-W* axis, *jBc* cos *B*.

2 Along the *N-S* axis, *jBc* sin *B*.

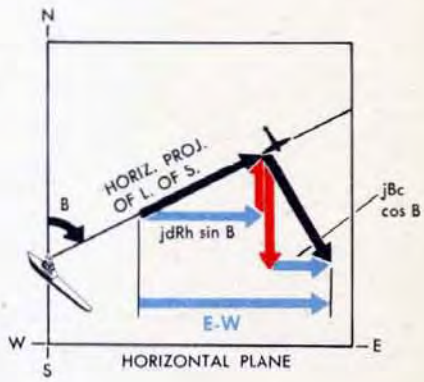
The components of jdRh and jBc are combined

The *jdRh* and *jBc* Integrators each produce one *N-S* and one *E-W* component.



The two *N-S* components, one from each component integrator, are combined to obtain the total *N-S* correction. Since they are in opposite directions in this example one component is subtracted from the other.

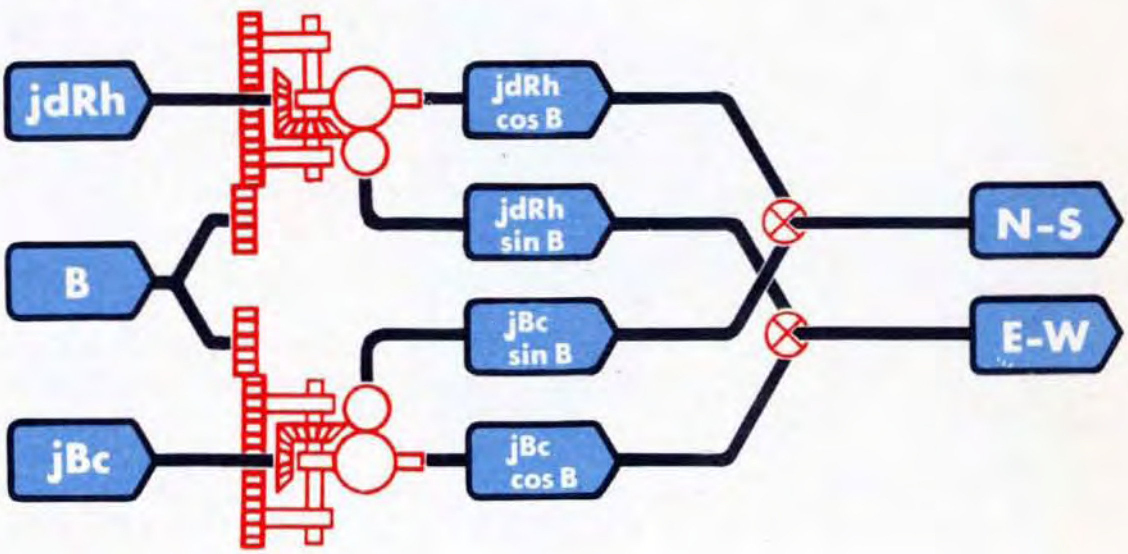
$$jBc \sin B - jdRh \cos B = \text{total } N\text{-}S \text{ correction.}$$



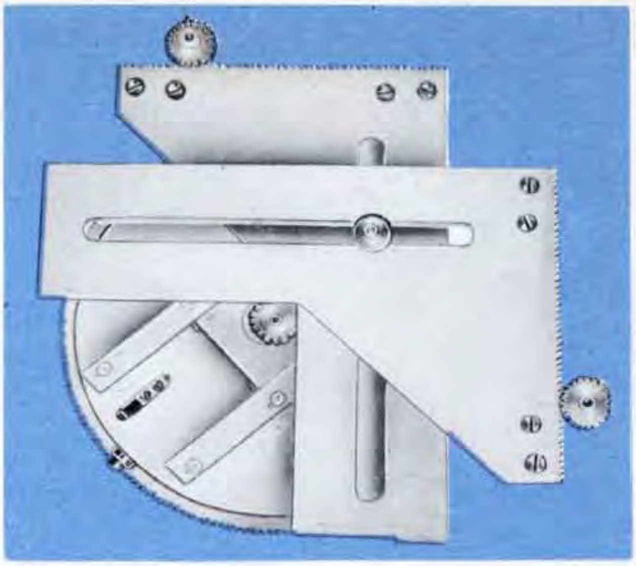
The two *E-W* components, one from each component integrator, are combined to obtain the total *E-W* correction. Since they are in the same direction in this example, the components are added.

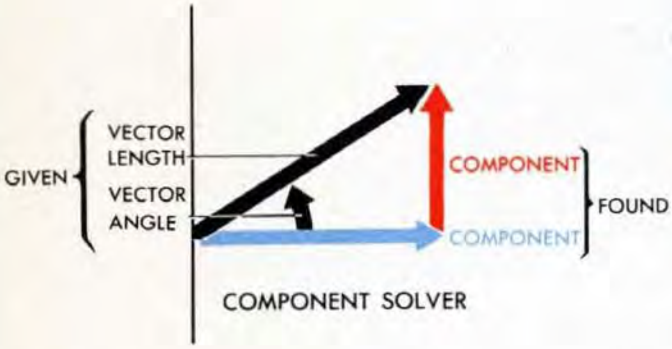
$$jBc \cos B + jdRh \sin B = \text{total } E\text{-}W \text{ correction.}$$

These *N-S* and *E-W* corrections are sent to the Vector Solver, where they correct the estimated values of Horizontal Target Speed, *Sh*, and Target Course, *Ct*.

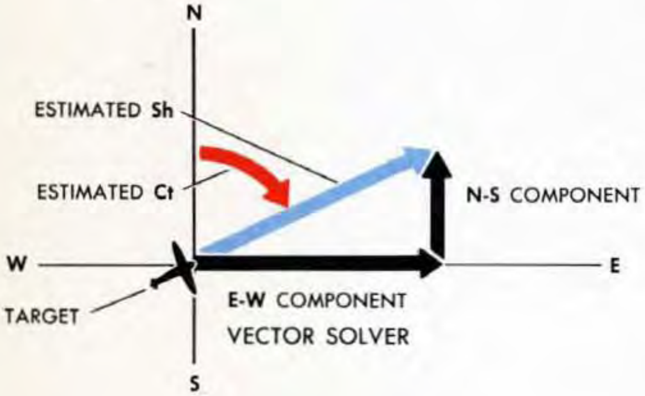


The VECTOR SOLVER

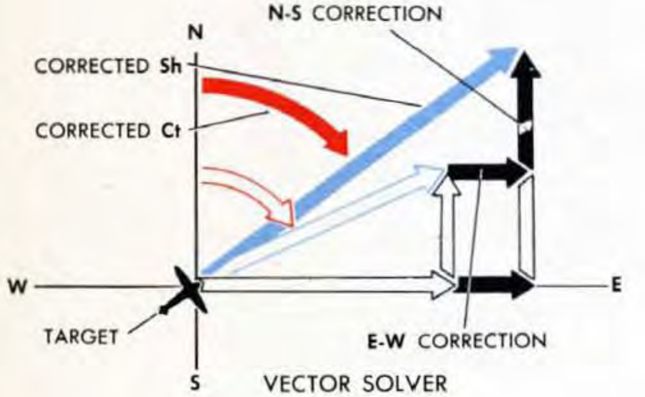




The Vector Solver is a component solver which can also work in reverse. For details, see OP 1140, page 106.



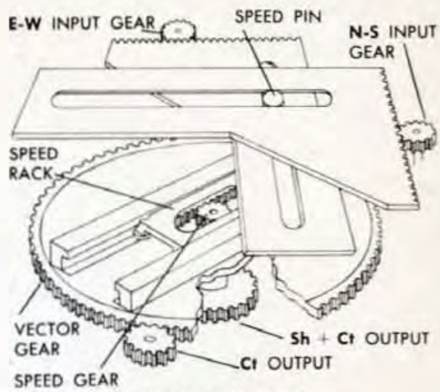
The estimated manual inputs of Horizontal Target Speed, *Sh*, and Target Course, *Ct*, set up a vector in the Vector Solver. This vector positions the Vector Solver racks at the values of the *N-S* and *E-W* components of this vector. During this operation, the Vector Solver acts as an ordinary component solver.



When the *N-S* and *E-W* Rate Corrections coming from the component integrators reposition these same racks, the racks change the length and direction of the vector and so correct the values of *Sh* and *Ct*.

During Rate Control, the *N-S* and *E-W* Corrections continuously position the Vector Solver. As the Relative Motion Rates become more nearly correct, each *N-S* and *E-W* Correction is smaller than the previous one until *Sh* and *Ct* are correct. When *Sh* and *Ct* are correct, the Relative Motion Rates and the Generated Changes of Target Position are correct, and no further Rate Control corrections are needed.

The vector solver outputs

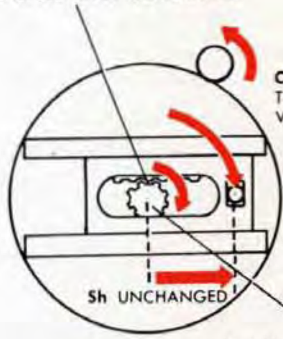


VECTOR SOLVER

The output from the vector gear is *Ct*, and the output from the speed gear is *Sh* + *Ct*.

The distance between the speed pin and the center of the vector gear represents the length of the vector, *Sh*. The position of the vector gear represents the direction of the vector, *Ct*.

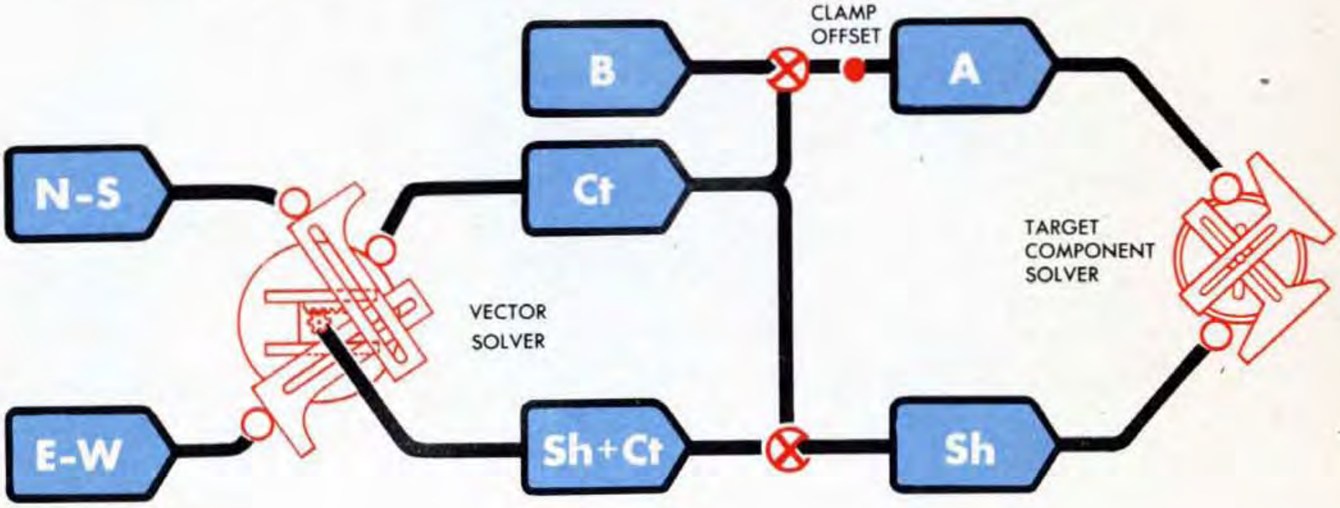
When there is a change in the *direction* of the vector only, both the vector gear AND THE SPEED OUTPUT GEAR must be turned together in order to keep the same vector length or speed. The speed gear is therefore turned for every input of *Ct* as well as for inputs of *Sh*, and the position of this speed gear always represents *Sh* + *Ct*. The Vector Solver output, *Ct*, is subtracted from the output, *Sh* + *Ct*, to keep Target Speed, *Sh*, correct.



A corrected value of Target Angle, *A*, is obtained by subtracting the Vector Solver output, *Ct*, from True Target Bearing, *B*, plus 180°.

$$B + 180^\circ - Ct = A$$

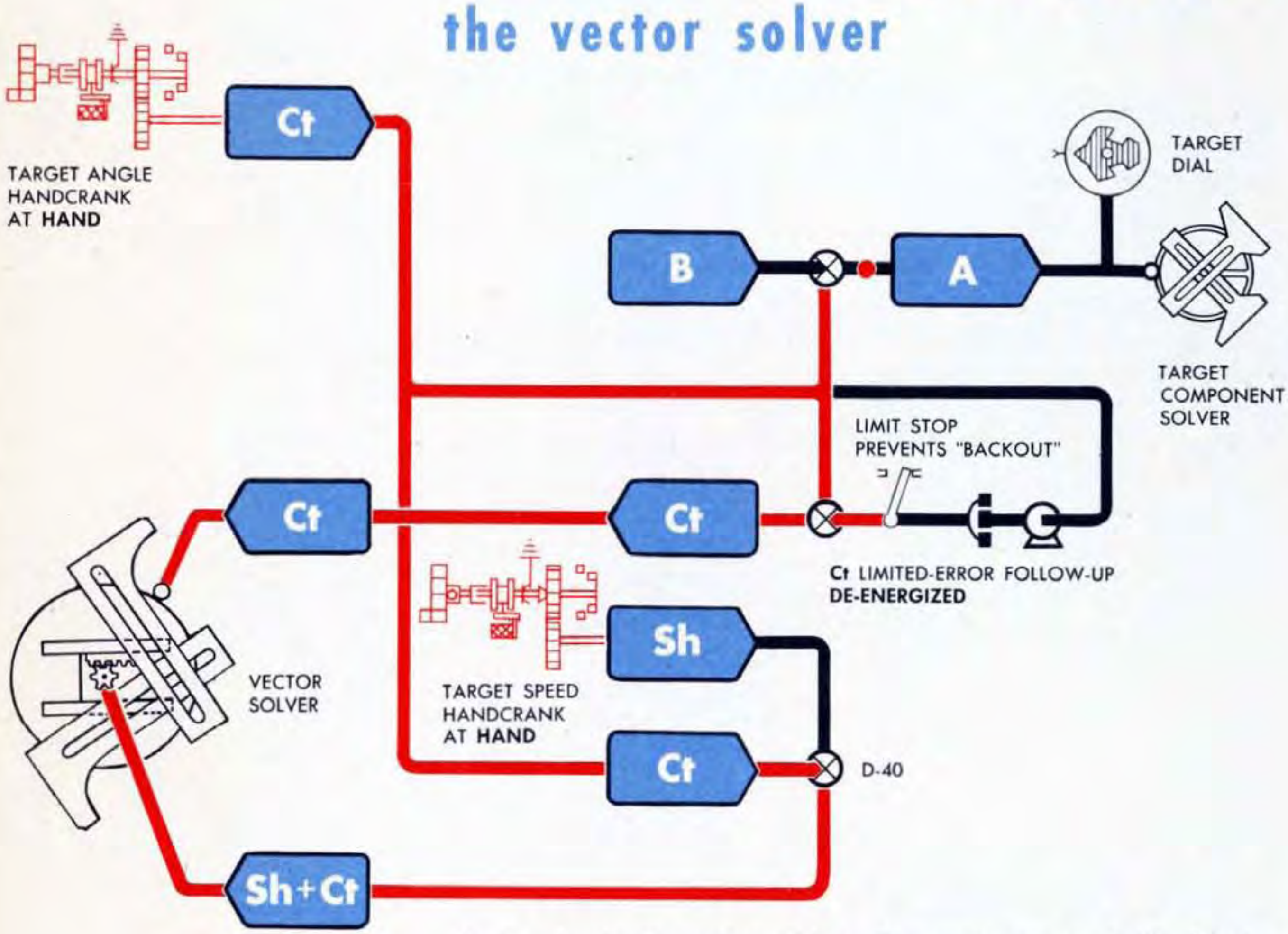
The corrected values of Target Angle, *A*, and Target Speed, *Sh*, go to the Target Component Solver in the Relative Motion Group. The Vector Solver is aided in positioning both the *Sh* and *Ct* lines by a special limited-error follow-up on each line.



Positioning the Ct line

The *Ct* line can be positioned *by hand* by turning the Target Angle Handcrank, and can be positioned *automatically* by using the *Ct* Limited-error Follow-up which amplifies the output of the Vector Solver.

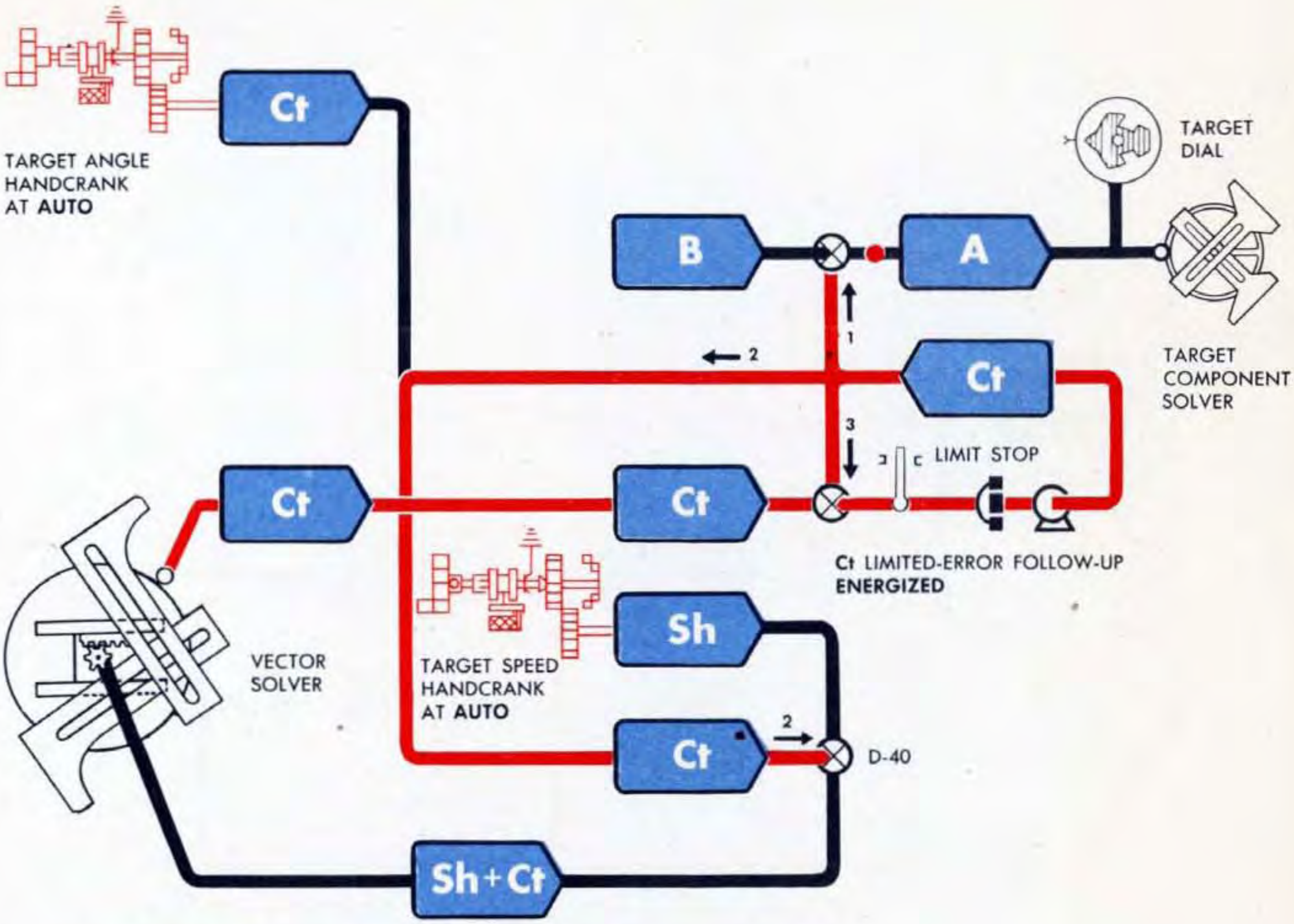
How manual Ct inputs position the vector solver



At the beginning of tracking, the vector gear of the Vector Solver is positioned by turning the Target Angle Handcrank with its lever at HAND position. The red line shows how *Ct* positions the vector gear and is subtracted from *B* to produce *A*. The value *A* positions the Target Dial and the Target Component Solver.

When the lever of the Target Angle Handcrank is at HAND, the *Ct* Follow-up Motor is de-energized. To prevent the hand input of *Ct* from throwing the follow-up out of synchronism, a limited-error follow-up control is used. A limit stop on this type of follow-up limits the motion of the differential spider which controls the contacts. Values of *Ct* coming from the Target Angle Handcrank feed into one side of this differential and out of the other side, since the motion of the spider is limited to about 3 degrees. The two sides of the differential are therefore always nearly matched, and the contacts remain approximately centralized at all times, whether the follow-up motor is energized or not.

How Ct from the vector solver positions the Ct line



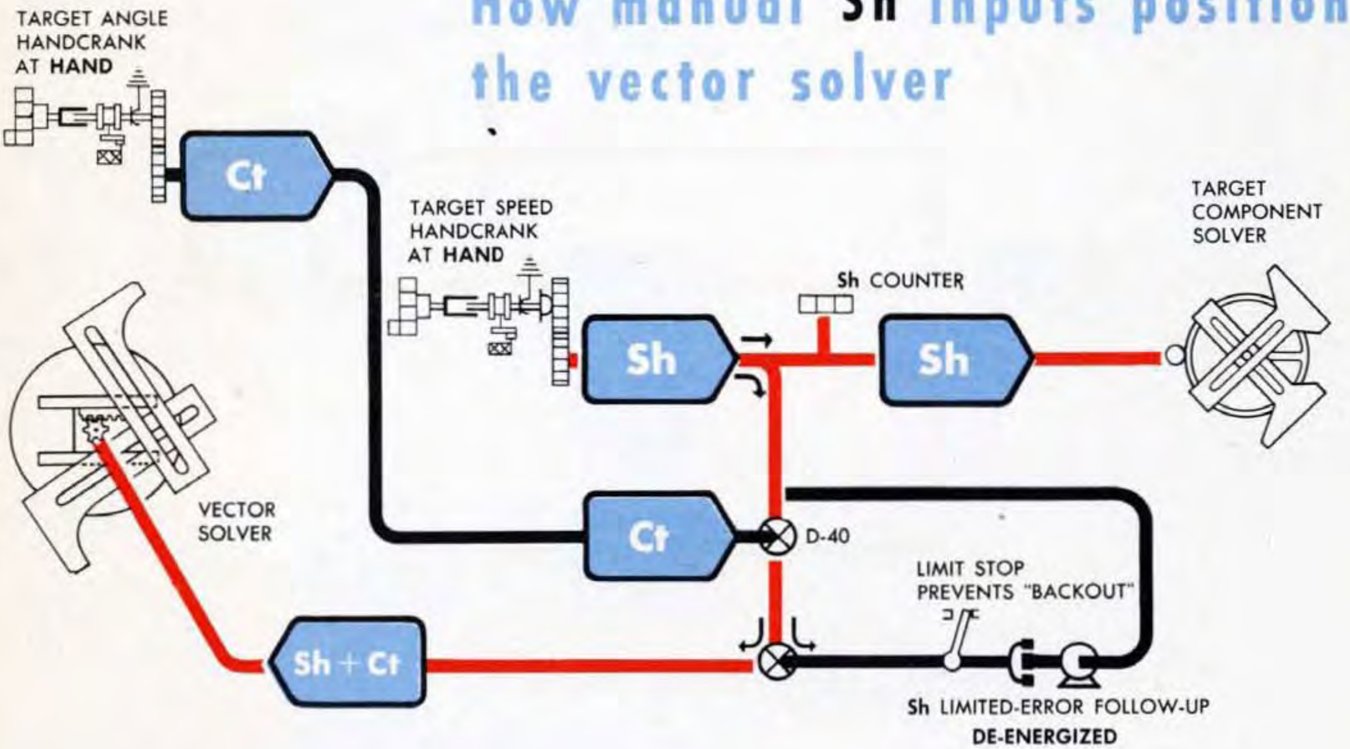
After the initial estimate of *A* is put into the Computer, the levers of the *A* and *Sh* Handcranks are turned to AUTO, energizing the *Ct* Follow-up. No time is wasted waiting for the *Ct* Follow-up to synchronize because the follow-up was kept close to synchronism during operation by hand. As soon as *N-S* and *E-W* Rate Corrections are computed by the Rate Control Computing Mechanism, the vector gear of the Vector Solver repositions the *Ct* line. This value of *Ct* feeds into one side of the follow-up differential, moves the spider, and offsets the follow-up contacts. The follow-up drives the *Ct* line to position three differentials:

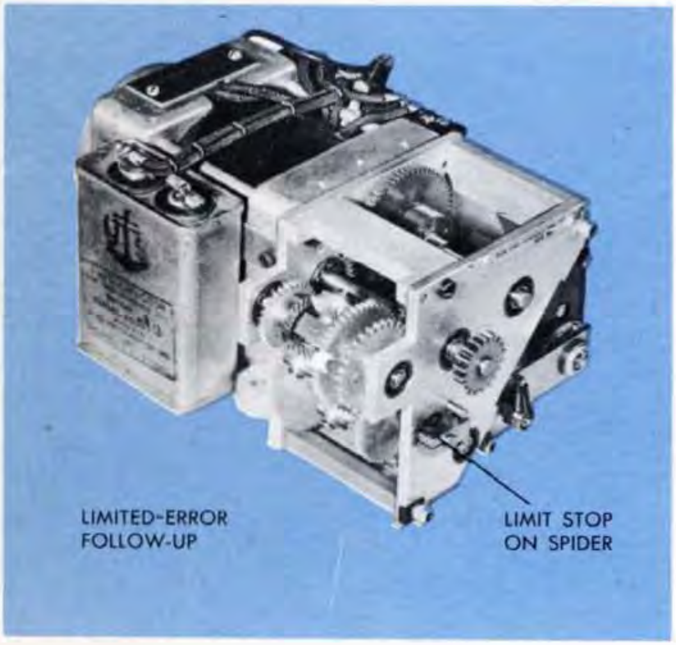
1. The differential at which *Ct* is subtracted from *B* to obtain *A*.
2. The differential at which *Ct* is subtracted from the *Sh* + *Ct* output of the Vector Solver to keep *Sh* at its proper value.
3. The differential of the *Ct* Follow-up, as the response to the signal from the Vector Solver.

Positioning the Sh line

The *Sh* line may be positioned by hand by turning the Target Speed Handcrank, or it may be positioned *automatically* by the *Sh* Limited-error Follow-up which amplifies the output of the Vector Solver.

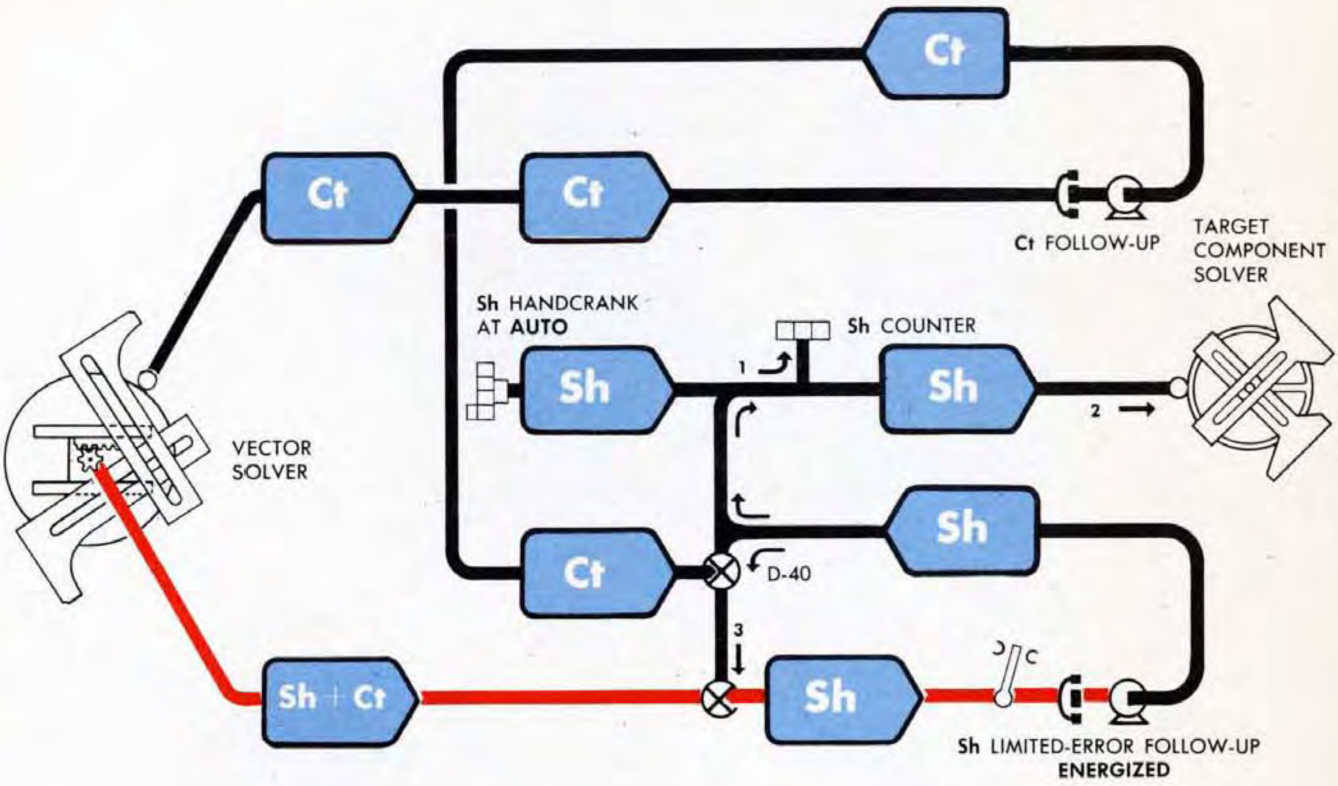
How manual Sh inputs position the vector solver





When tracking begins, the lever on the Target Speed Handcrank is switched to HAND position, de-energizing the *Sh* Follow-up. The initial *Sh* estimate can then be put into the Computer by hand. The red line shows how *Sh* positions the *Sh* Counter and the Target Component Solver. At differential D-40, *Sh* is added to *Ct*. *Sh* + *Ct* feeds into one side of the differential of the *Sh* Limited-error Follow-up. Since the spider is held by the limit stop, *Sh* + *Ct* drives out of the other side of the differential and positions the Vector Solver speed gear. The follow-up contacts remain approximately centralized at all times.

How Sh from the vector solver positions the Sh line



After the manual setting of *Sh*, the lever on the *Sh* and *A* Handcranks are switched to AUTO, energizing the *Sh* Follow-up. *N-S* and *E-W* Rate Corrections are computed by the Rate Control Computing Mechanism, and the Vector Solver speed gear positions the *Sh* + *Ct* line.

Sh + *Ct* from the Vector Solver drives into one side of the differential of the Limited-error Follow-up, where *Ct* is subtracted from *Sh* + *Ct*. *Sh* then offsets the contacts of the follow-up. The follow-up drives the *Sh* line to position three mechanisms:

1 The Target Speed Counter
2 The Target Component Solver
3 The differential of the *Sh* Follow-up, as response.

MAKING RATE CORRECTIONS IN SEMI-AUTO

After seeing how the Rate Corrections are turned into corrections to Target Motion values, it is necessary to know what determines the size of these corrections and how they are put into the Rate Control Computing Mechanism.

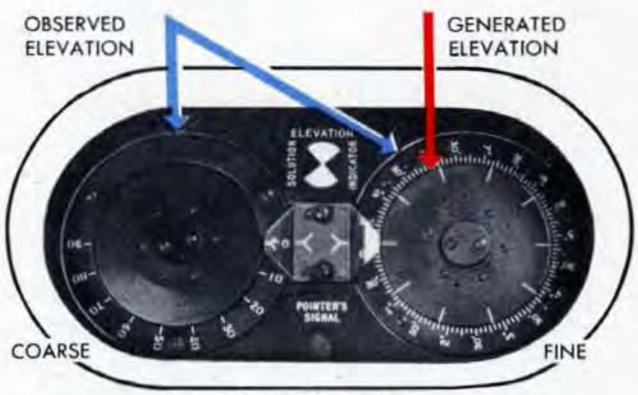
In Semi-automatic Operation, the Computer Operators turn the Generated Cranks to put Rate Corrections into the Rate Control Computing Mechanism to keep the Generated and Observed Dials turning together.

Turning the Generated Cranks when they are in their IN positions introduces the Rate Corrections into the Rate Control Mechanism.

Whenever the Generated Dials are rotating faster or slower than the respective Observed Dials, Rate Corrections are needed.

Turning the Generated Elevation and Bearing Cranks so as to cause the *fine* Generated Dials to turn with the respective Observed Dials introduces the necessary Elevation and Bearing Rate Corrections.

Turning the Generated Range Crank so as to match the Generated Range Dials with the Observed Range Dials introduces the Range Rate Correction.



ELEVATION DIALS

Keeping generated elevation matched with observed elevation

Observed Target Elevation, *E*, turns the outer Elevation Dials, both coarse and fine.

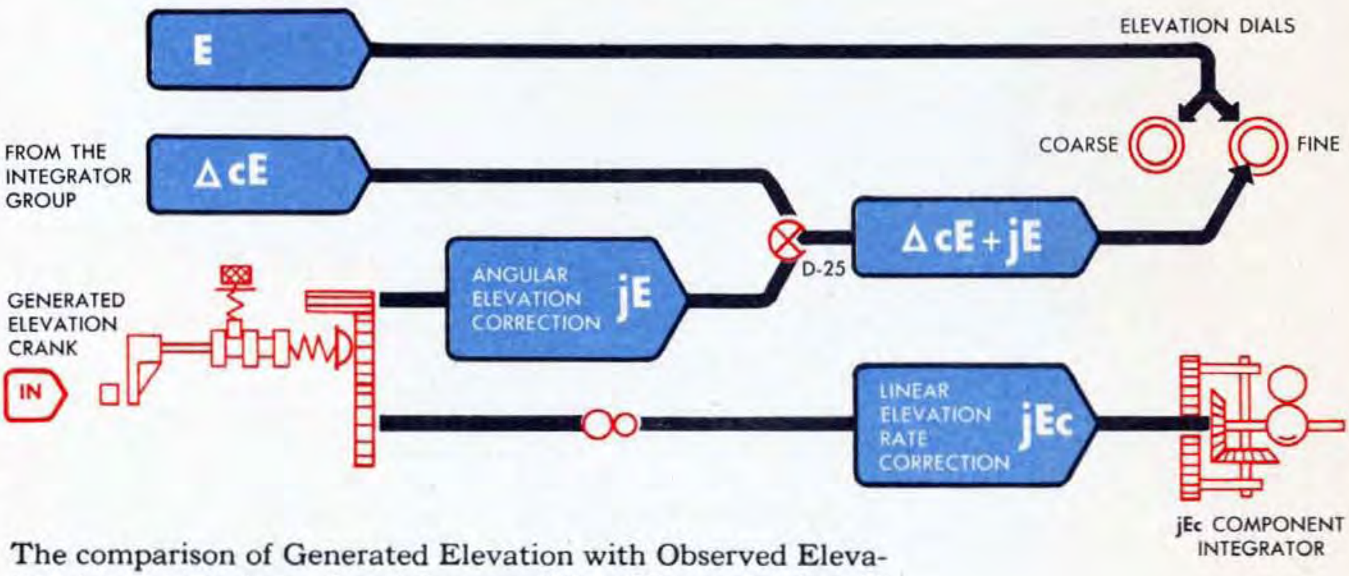
The Generated Changes of Elevation, $\triangle cE$, from the Integrator Group in the Computer, turn the Generated Elevation Dial.

If the Generated Elevation Dial turns faster or slower than the fine Observed Elevation Dial, and the Pointer's Signal is red indicating that the Pointer's sight is on the Target, the Elevation Operator turns the *jE* Crank in its IN position until the graduations on the dials rotate together.

The elevation rate correction jEc

When the Elevation Operator turns the *jE* Crank in its IN position, he does two things:

1. He puts *Angular* Elevation Correction, *jE*, into the Generated Elevation line.
2. He drives *Angular* Elevation Correction, *jE*, through ratio gearing to produce an approximate *Linear* Elevation Rate Correction, *jEc*. *jEc* drives into the *jEc* Component Integrator in the Rate Control Computing Mechanism.



The comparison of Generated Elevation with Observed Elevation is a comparison of *angular* quantities. The correction *jE* which is based on this comparison is also an angular quantity.

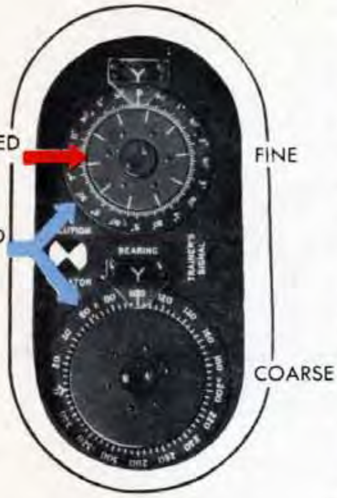
The job of the Rate Control Computing Mechanism is to correct *Sh*, *dH*, and *A*. Since *Sh* and *dH* are linear rates, *Angular* Elevation Correction, *jE*, must be converted into a *linear rate* correction before it can be used in correcting *Sh* and *dH*. The Linear Elevation Rate Correction, *jEc*, is obtained by driving *jE* through ratio gearing. This shortcut method of converting angular values into linear values is only approximate, but it produces values which are sufficiently accurate, and saves using extra mechanisms.

In the Rate Control Computing Mechanism, *jEc* is used together with Deflection Rate Correction, *jBc*, and Range Rate Correction, *jdR*, to compute corrections to Target Speed, Target Angle, and Rate of Climb. The corrected Target Motion values, *Sh*, *dH*, and *A*, feed into the Relative Motion Group where corrected Relative Motion Rates are computed. The corrected Elevation Rate, *RdE*, from this group goes to the Integrator Group and corrects the rate at which Changes of Elevation, △*cE*, are generated.

When Elevation Rate, *RdE*, is correct, △*cE* is being generated at the same rate that *E* is changing, and the inner and outer Elevation Dials turn together.

This solves the Elevation part of the Tracking Problem.

Making bearing rate corrections in SEMI-AUTO



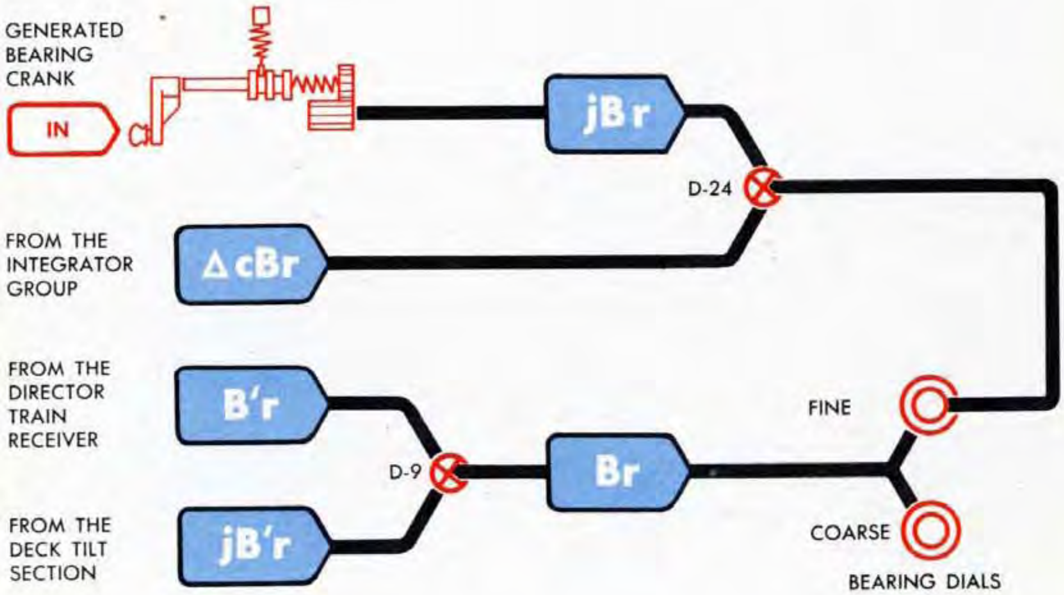
These are the Bearing Dials. They operate in the same way as the Elevation Dials.

Relative Target Bearing, *Br*, positions the outer Bearing Dials, both fine and coarse. Generated Changes of Relative Target Bearing, △c*Br*, from the Integrator Group position the Generated Bearing Dial, which is the inner dial of the fine pair.

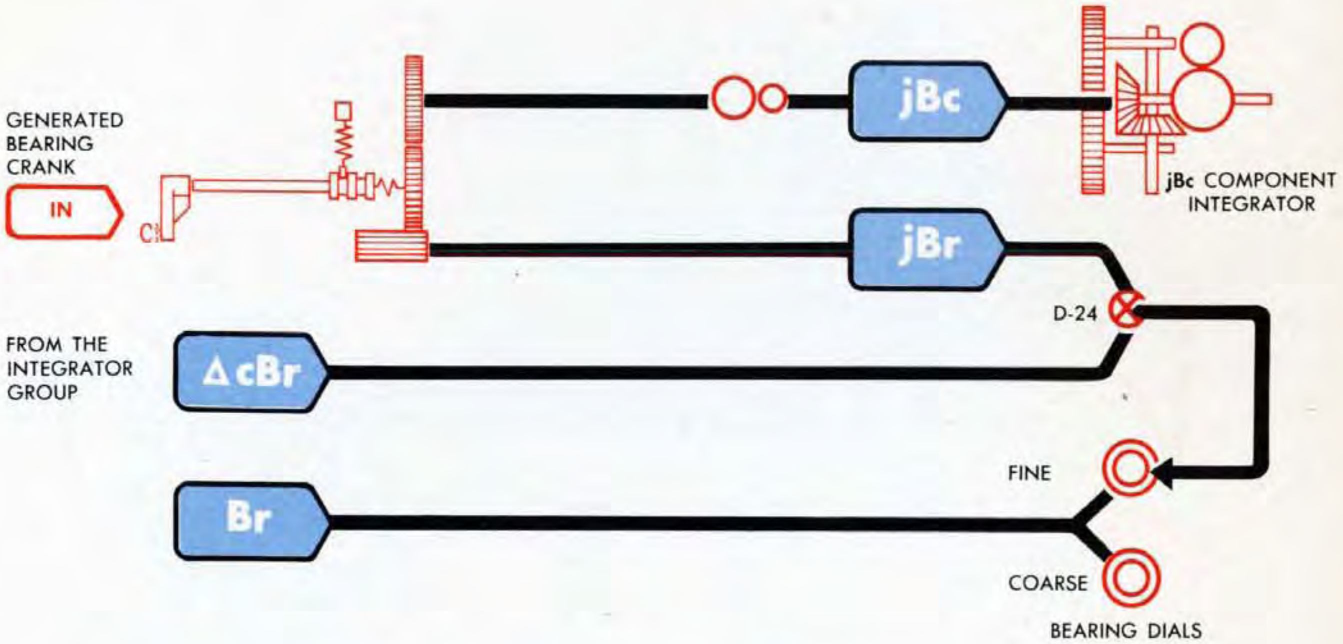
If the Generated Relative Target Bearing Dial turns faster or slower than the fine Observed Relative Target Bearing Dial, and if the Trainer's Signal is red indicating that the Trainer's sight is on the Target, the Bearing Operator corrects Generated Bearing by turning the *jBr* Crank in its IN position.

He continues to turn the crank until the Generated Dial revolves with the fine Observed Dial.

As in the case of Elevation, there are no numbers on the inner Bearing Dial since Generated Bearing is used to turn this dial only. The Bearing Operator is interested only in the *rate* at which Generated Bearing changes, not in its exact value at any moment.



Deflection rate correction jBc



When the Bearing Operator turns the *jBr* Crank in its IN position, he does two things:

1. He puts angular correction *jBr* into the Generated Bearing line.
2. He drives *angular* correction *jBr* through ratio gearing producing an approximate *linear* Deflection Rate Correction, *jBc*. *jBc* drives into the *jBc* Component Integrator in the Rate Control Computing Mechanism.

In the Rate Control Mechanism, Deflection Rate Correction, *jBc*, is used together with Elevation Rate Correction, *jEc*, and Range Rate Correction, *jdR*, to compute corrections to Target Speed, Target Angle, and Rate of Climb. The corrected Target Motion values, *Sh*, *dH*, and *A*, feed into the Relative Motion Group, where corrected Relative Motion Rates are computed. The corrected Deflection Rate, *RdBs*, goes to the Integrator Group and corrects the rate at which Changes of Relative Target Bearing, △*cBr*, are generated. △*cBr* drives the Generated Bearing Dial. *When RdBs is correct, △cBr is generated at the same rate as Br is changing, and the inner and outer Bearing Dials turn together*. The Bearing part of the problem is solved.

The GENERATED RANGE LINE IN SEMI-AUTO

It is important to understand why the Range lines used for computations in the Computer Mark 1 are positioned by Generated Range instead of Observed Range. Because the Range Finder can only be focused intermittently, the values of Observed Range, *R*, are only intermittently correct, and the positioning of the Range line by Observed Range would be jerky and often incorrect. In order to fire continuously, accurate values of Range must be available continuously. Intermittent values are not sufficient. Generated Range, *cR*, is computed continuously by adding $\triangle cR$ from the Range Integrator to Initial Range, *jR*. Generated Range therefore drives the numbered outer dials in the Range Dial Group. Observed Range drives the inner Range Dials, which are attached directly to the synchros of the Range Receiver.

In rate-controlling *Elevation* and *Bearing*, the Computer Operators put in Rate Corrections until the inner Elevation and Bearing Dials turn in synchronism with their respective outer dials.

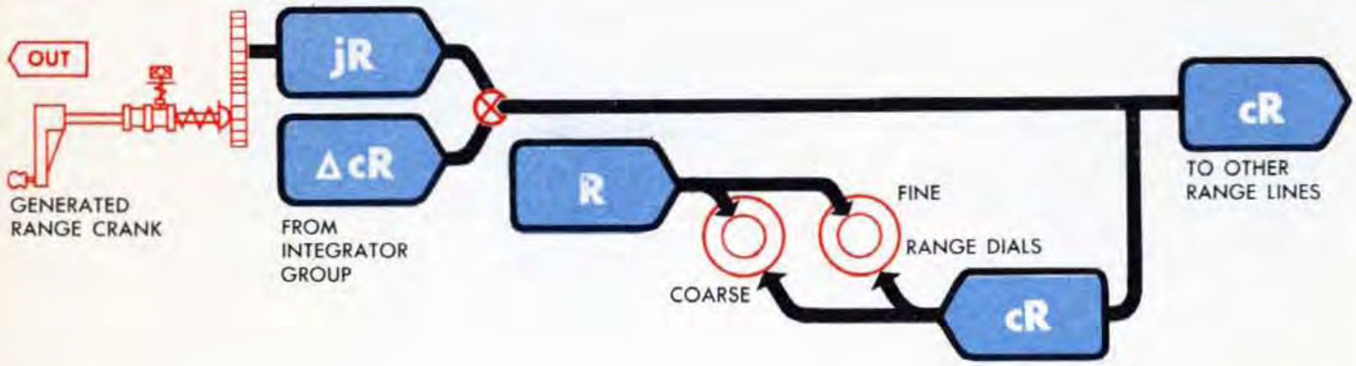
In rate-controlling *Range*, the Operator puts in corrections, not only to keep the dials turning together, *but also to keep the indexes on the Generated Range Dials matched to the indexes on the Observed Range Dials.* When the indexes are matched and stay matched, *cR* and *R* are changing at the same rate, *and the value of cR is exactly equal to the value of R.*

Making range and range rate corrections

Generated Range can be matched to Observed Range by turning the Generated Range Crank in either of its positions:

1. Turning the Generated Range Crank in its OUT position corrects the value of *cR* only.
2. Turning the Generated Range Crank in its IN position corrects both the value of *cR* and the *rate* at which *cR* is being generated.

As soon as tracking begins and the initial value of Observed Range has positioned the *inner* Range Dials, the Range Operator at the Computer must match the *outer* Generated Range Dials to the inner Observed Range Dials.



To match the dials, the Operator turns the Generated Range Crank in its OUT position, until the Y-shaped indexes on both sets of Range Dials are lined up. This initial setting of Generated Range is called *jR*. When the Generated Dials are matched to the Observed Dials, *jR* is equal to *R*. Matching the indexes puts an accurate value of Range onto all Range lines in the Computer, since *jR* is the only Range value going into the *cR* line at this moment.

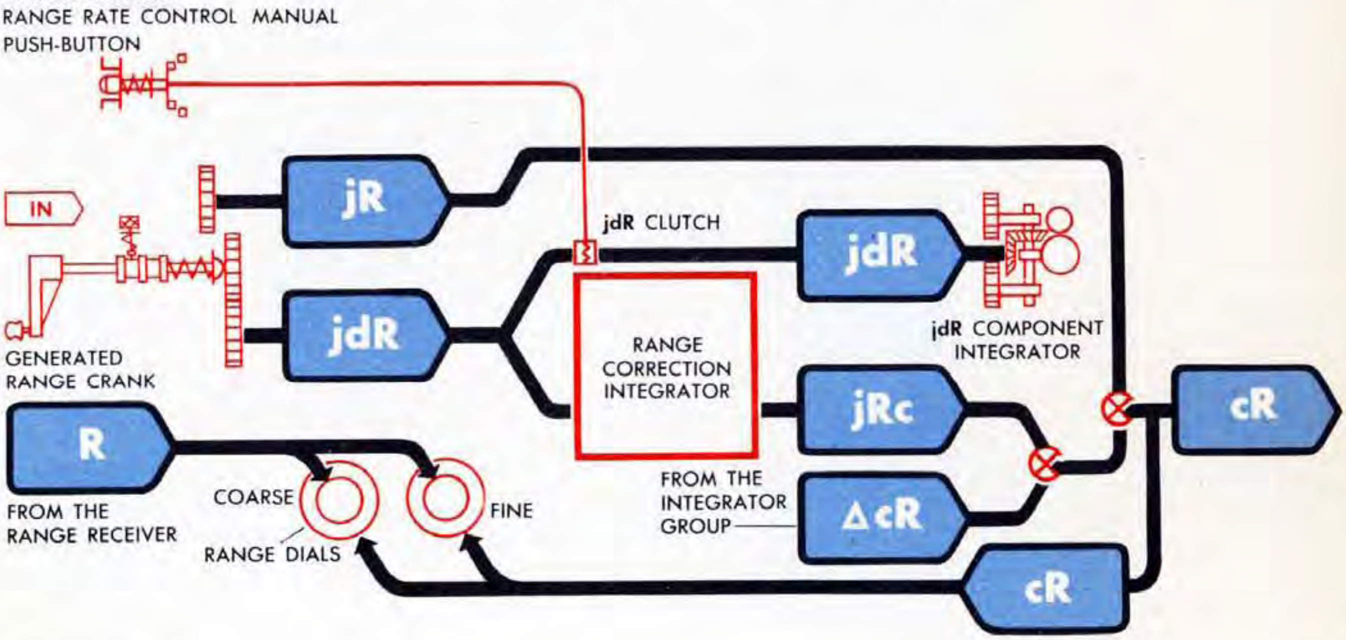
Now the Time Motor is turned on. Immediately the Range Integrator begins to compute continuous Changes of Generated Range, △*cR*, which are added to the initial *jR* input, giving continuous values of Generated Range, *cR*. If *cR* changes at the same rate as *R*, both sets of Range Dials *turn together and the indexes remain matched.* But if *cR* does not change at the same rate as *R*, the Generated Dials will turn at different rates from the Observed Dials and their fixed indexes will not remain matched.

If the dials do not remain matched, two Range corrections are needed: a Linear Range Correction, *jRc*, to match Generated Range to Observed Range at the dials, and a Range Rate Correction, *jdR*, to make the Generated and Observed Range Dials turn at the same rate.

Turning the Generated Range Crank in its IN position puts a Linear Range Correction into the *cR* line to match the indexes on the Generated Range Dials to the indexes on the Observed Range Dials.

Range Rate Corrections as well as Linear Range Corrections may be introduced by turning the Generated Range Crank in its IN position, but only when the necessary electrical circuits are completed. The Range Rate Control Switch must be at MANUAL. Also, the Range Rate Control Manual Push-button must be depressed while the Generated Range Crank is turned. This energizes the *jdR* clutch, enabling Range Rate Corrections to enter the *jdR* Component Integrator. Through the Rate Control Computing Mechanism, *jdR* corrects the rate of change of Generated Range. This correction alters the rate of rotation of the Generated Range Dials.

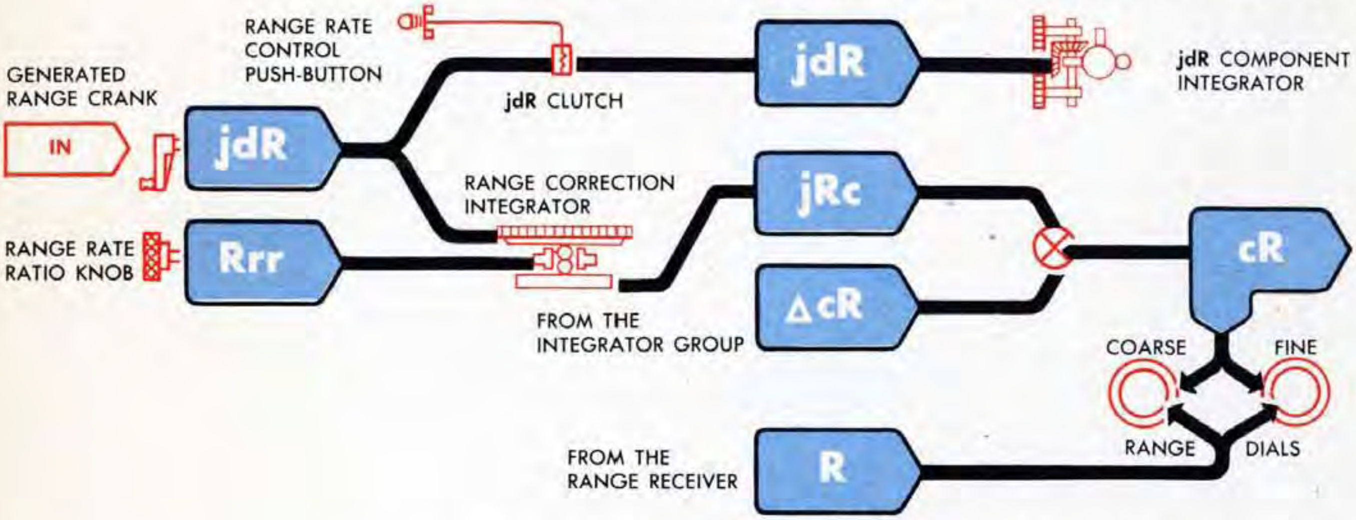
The ratio between the Linear Range Correction and the Range Rate Correction may be varied by changing the position of the Range Correction Integrator carriage. This is accomplished by turning the Range Rate Ratio Knob.



The RANGE CORRECTION INTEGRATOR

The Range Rate Correction, *jdR,* set in by turning the Generated Range Crank in the IN position does two jobs:

1. As a Rate Correction, *jdR* is an input to the *jdR* Component Integrator in the Rate Control Computing Mechanism.
2. *jdR* drives the disk of the Range Correction Integrator and produces the Linear Range Correction, *jRc. jRc* repositions the *cR* line to match Generated Range to Observed Range.



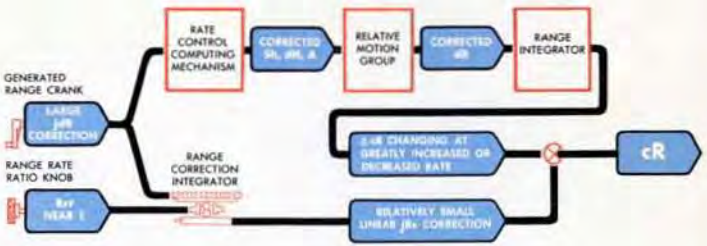
The ratio between the sizes of the Rate Correction, *jdR,* and the Linear Correction, *jRc,* is controlled by the position of the carriage of the Range Correction Integrator. This carriage is positioned by turning the Range Rate Ratio, *Rrr,* Knob. The size of *Rate* Correction, *jdR,* is determined by the amount of *jRc* needed to match the Range Dials. The *jdR* Crank is turned until the Range Dials match. The carriage setting made by the *Rrr* Knob is altered as tracking progresses because the ratio between the necessary *Linear* Range Correction and the necessary Range *Rate* Correction must be altered as the Range Rate error decreases.

Linear Correction, *jRc,* will always be relatively small when the Generated Range Dials are continually being matched to agree with the Observed Range values. The size of *Rate* Correction, *jdR,* however, will depend on the degree of inaccuracy of the Target Motion estimates. A large Rate Correction will usually be needed at the beginning of tracking before the estimates of *Sh, dH,* and *A* have received any corrections through Rate Control. As tracking progresses, and *Sh, dH,* and *A* become more nearly correct, a smaller Rate Correction will be needed.

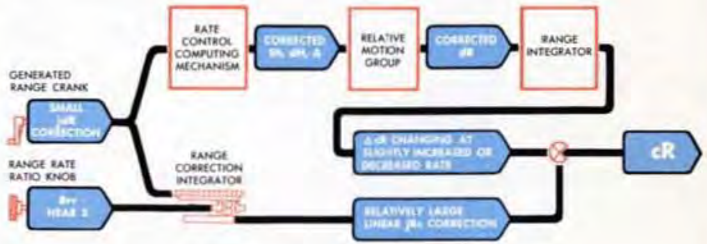
Without the Range Correction Integrator it would take a long time to put in a large correction to Range Rate. Many small corrections to Linear Range, *cR,* would have to be made before the rate of change of *cR* would be correct.

The Range Correction Integrator makes it possible to put in a larger or smaller Range Rate Correction while putting in the amount of Linear Range Correction required to match *cR* to *R* at the dials.

How the integrator carriage is positioned



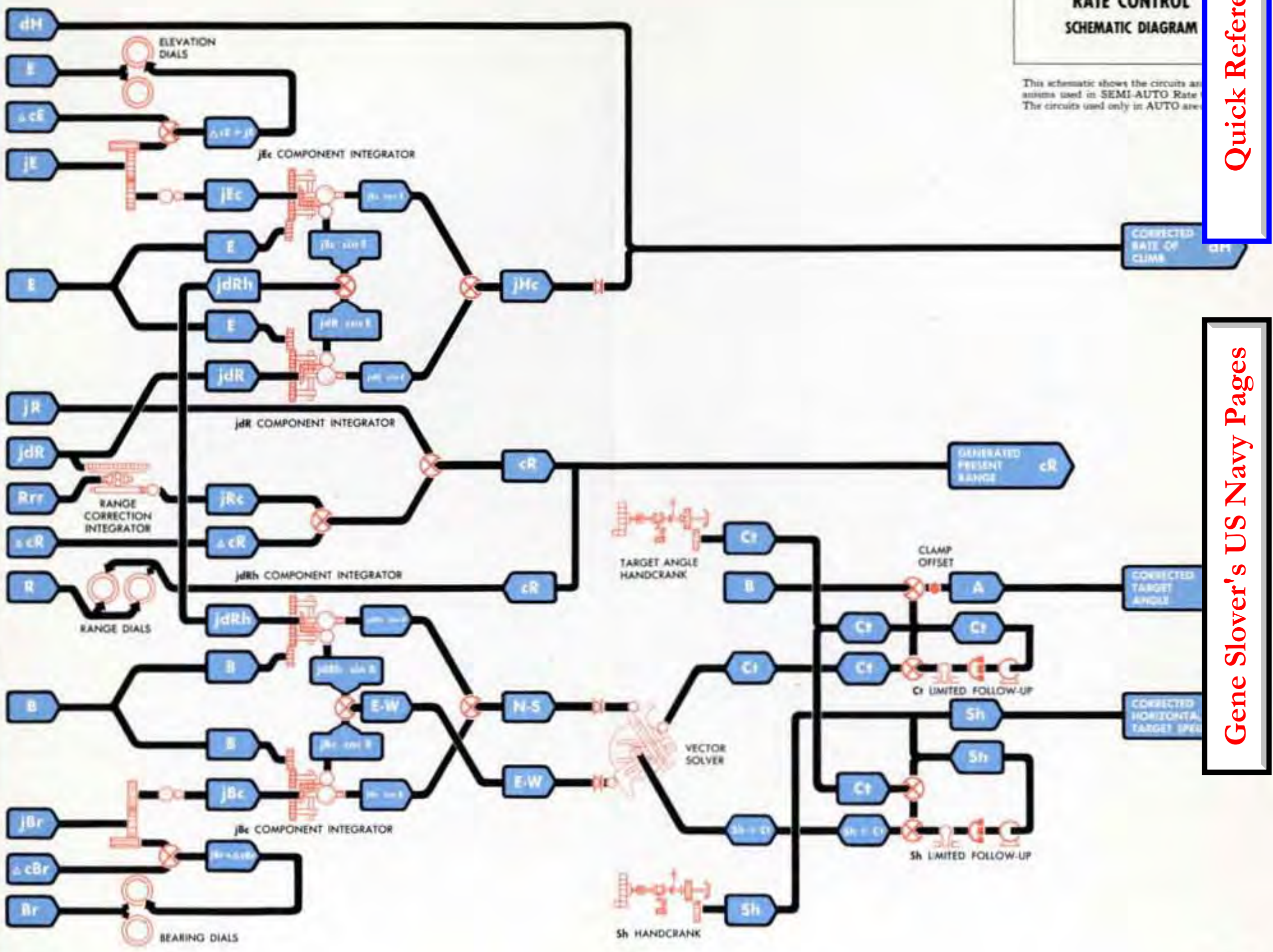
When the difference between *cR* and *R* is small, but there is a *big* difference between the rates at which *cR* and *R* are changing, the *Rrr* Knob is turned toward 1, positioning the Range Correction Integrator carriage near the center of the integrator disk. With the carriage near the center, a relatively *small* linear correction, *jRc*, comes from the integrator roller for many revolutions of the integrator disk by *jdR*. *cR* receives a small *jRc* linear correction, just enough to match the Range Dials. A large *jdR* correction feeds into the Rate Control Computing Mechanism, causing the *rate of change* of *cR* to be greatly increased or decreased.



If the rates of change of *cR* and *R* differ only slightly, but the difference between *cR* and *R* is relatively large, the *Rrr* Knob is turned toward 5. This moves the Range Correction Integrator carriage toward the outer edge of the integrator disk. With the carriage near the edge of the disk, a relatively large *jRc* correction comes from the output roller for a small *jdP* value driving the integrator disk. The Linear Range Correction, *jRc*, is relatively *large*, but only a small value of *jdR* is going into the Rate Control Computing Mechanism. The correction to the *rate of change* of *cR* will be relatively *small*.

COMPUTER MK. 1, MOD
SEMI-AUTOMATIC RATE CONTROL
SCHEMATIC DIAGRAM

This schematic shows the circuits an[d]
axioms used in SEMI-AUTO Rate
The circuits used only in AUTO are



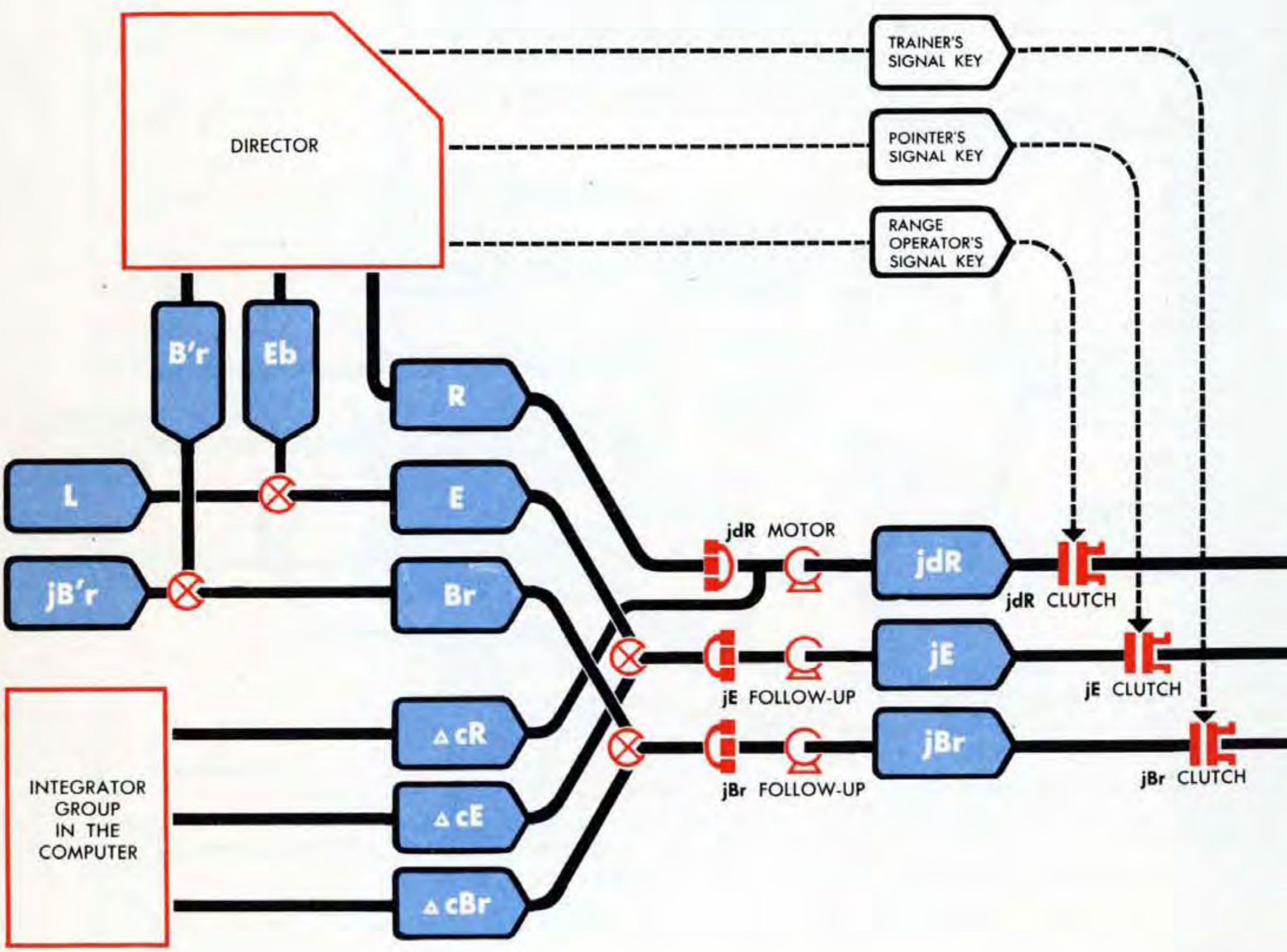
AUTOMATIC RATE CONTROL

The main difference between Automatic and Semi-automatic Rate Control lies in the method by which the Rate Corrections are put into the Rate Control Computing Mechanism.

In Semi-automatic Rate Control, the Rate Corrections, *jdR, jEc* and *jBc,* are put into the Rate Control Computing Mechanism by the Computer Crew.

In Automatic Rate Control, these Rate corrections are controlled by the Director Crew and are put into the Rate Control Computing Mechanism automatically whenever the Director Crew close their Rate Control signal keys while turning their handwheels to keep the sights on the Target.

This is a simplified block schematic of the RATE CONTROL GROUP in AUTOMATIC RATE CONTROL

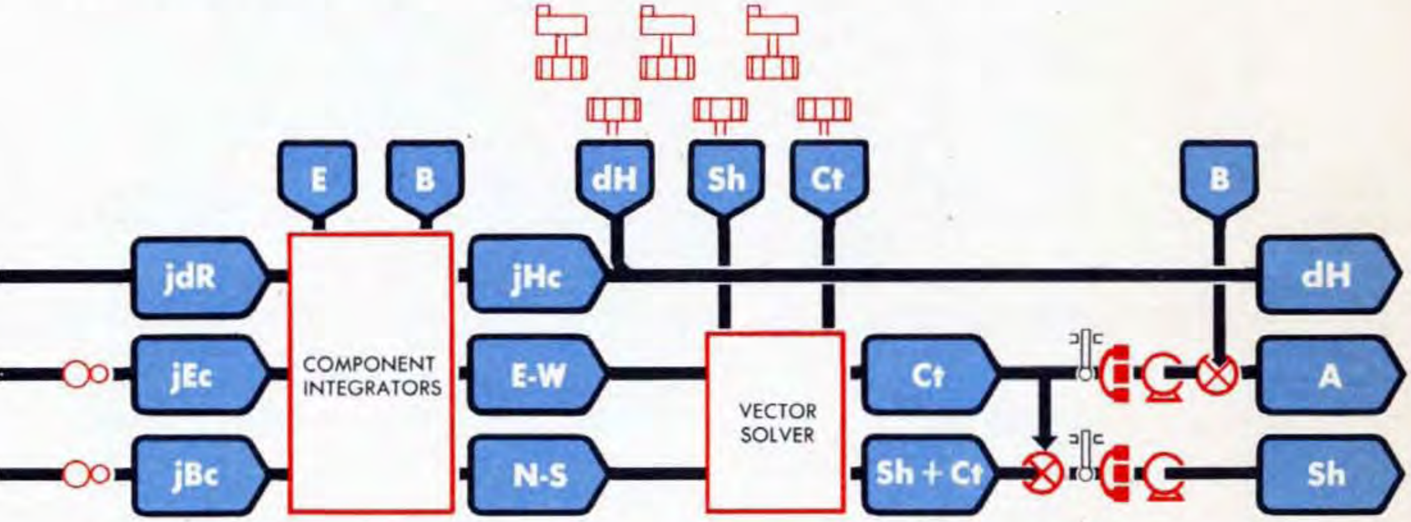


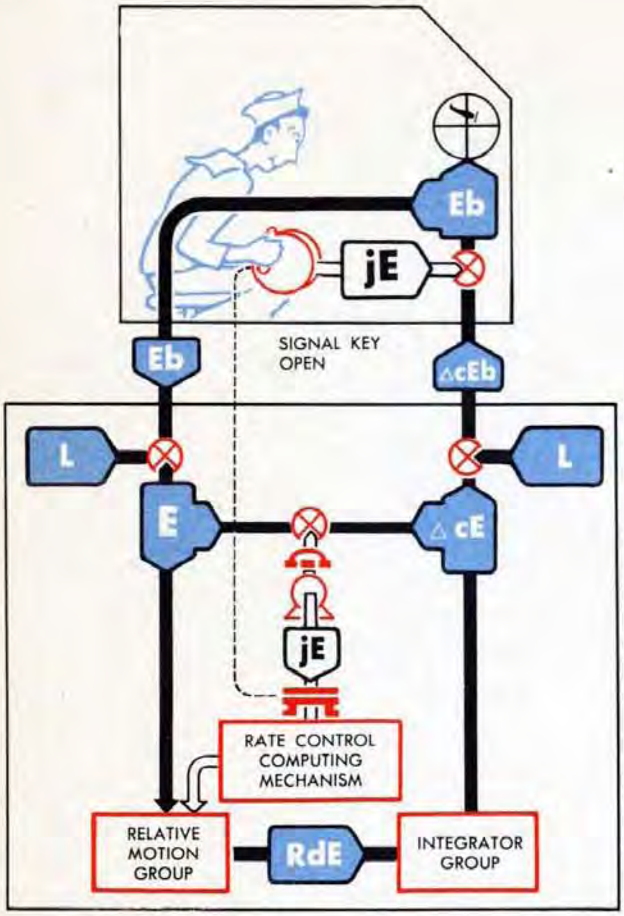
In Automatic, Semi-automatic, and Manual Rate Control, the Pointer, Trainer, and Range Operator turn their handwheels to put in corrections which make up the differences between the Generated Changes of Target Position and the Observed Changes of Target Position. They do this to keep their sights on the Target and to send down to the Computer the correct values of Observed Target Position at every instant.

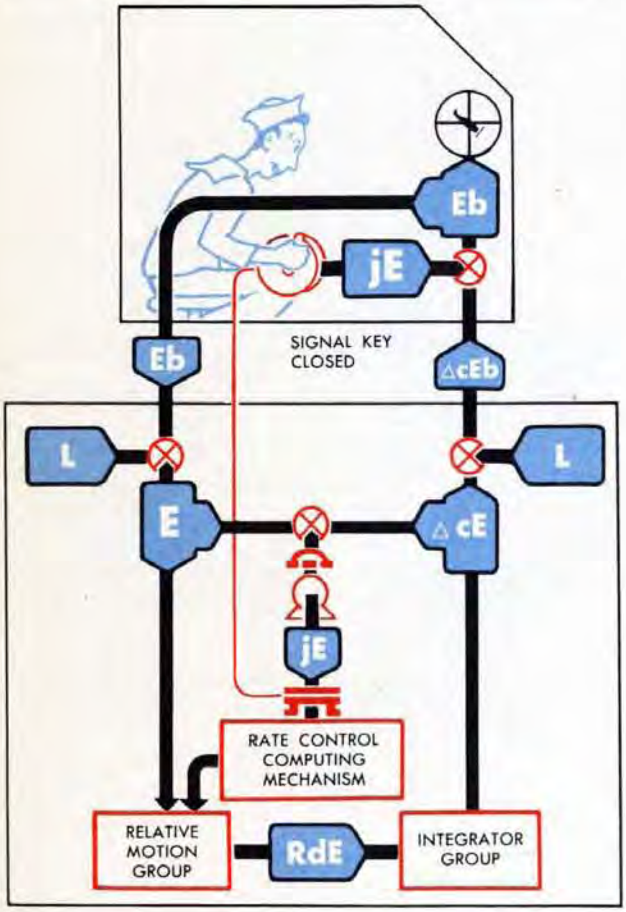
In Automatic Rate Control, the Director Operators have the additional responsibility of putting all or part of their handwheel corrections into the Rate Control Computing Mechanism in the Computer. They put these corrections in by closing their Rate Control signal keys as they turn their handwheels to keep the sights on the Target.

In the Computer, the Generated and Observed Target Position values are continuously being compared. The differences between the Observed and Generated Target Position values offset the contacts of the *jdR* Motor and the *jE* and *jBr* Follow-ups. When the Director Operators have their signal keys closed, clutches are engaged connecting the output lines from the motor and follow-ups to the Rate Control Computing Mechanism. The *jdR* Motor and the *jE* and *jBr* Follow-ups continuously drive the differences between the Observed and the Generated Target Position values into the Rate Control Computing Mechanism, as values of *jdR, jEc,* and *jBc.*

In FULL Automatic Operation, the Control Switch and Range Rate Control Switch are both turned to AUTO. The Control Switch energizes the *jE* Follow-up and the *jBr* Follow-up. The Range Rate Control Switch energizes the *jdR* Motor and Clutch when the Range Operator's Signal Key is closed. The different electrical circuits controlled by these switches are explained in detail on pages 258-261.







In Automatic Rate Control, the processes by which Generated Bearing and Generated Elevation are corrected are similar.

The pointer's job

Suppose that the Generated Changes of Elevation, $\triangle cEb$, are not keeping the Pointer's sight on the Target.

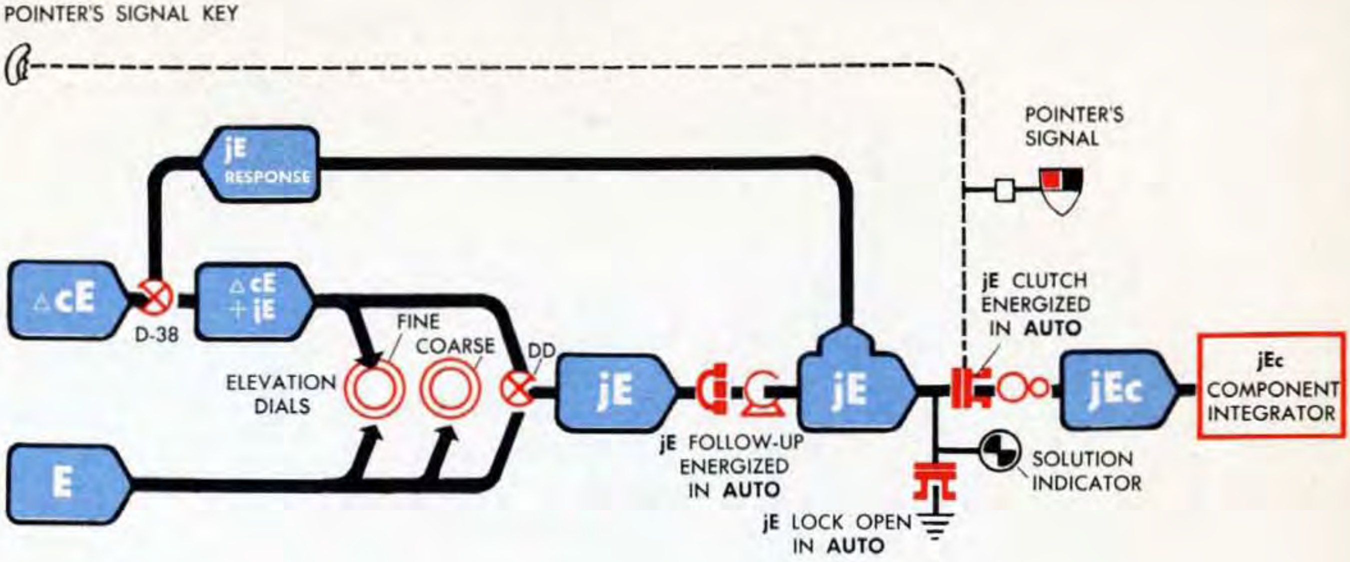
The Pointer's sight, driven by $\triangle cEb$ from the Integrator Group in the Computer, is above or below the Target and is steadily moving farther from the Target. The value of *Eb* going down to the Computer is *incorrect, E* is incorrect, and the Rate of Change of $\triangle cE$ is also incorrect.

The Pointer turns his handwheels an amount, *jE,* to put the crosshair of his sight onto the Target. The values of *Eb* and *E* in the Computer are now *correct*. When on the Target, the Pointer presses his signal key and continues to turn his handwheels to keep on Target.

The correction, *jE,* put in by the Pointer as he turns his handwheels is continuously added to $\triangle cEb$ to keep the value of *Eb* correct. In the Rate Control Group, the changes of *E* are continuously compared with $\triangle cE$. The difference between $\triangle cE$ and *E* is *jE,* the amount the Pointer puts in. *jE* offsets the contacts of the *jE* Follow-up. When the Pointer's Signal Key is closed as he turns his handwheels, the clutch on the *jE* line in the Computer is engaged and the follow-up drives *jE* into the Rate Control Computing Mechanism as Elevation Rate Correction, *jEc.*

The Rate Control Computing Mechanism computes corrections to Target Motion values, *Sh, dH,* and *A.* The corrected Target Motion values correct Elevation Rate, *RdE,* until the Integrator Group generates $\triangle cEb$ at a rate which keeps the Pointer's sight on the Target automatically without any handwheel correction.

When *RdE* is correct, $\triangle cEb$ changes at the same rate as *Eb,* and $\triangle cE$ changes together with *E.* No *jE* correction is needed.



Rate-controlling elevation in auto

Observed Changes of Target Elevation, *E*, and Generated Changes of Target Elevation, △*cE*, from the Integrator Group position the two sides of differential DD, where they are compared.

The difference between *E* and △*cE* is the differential output, *jE*. *jE* is the *Angular* Correction to Generated Elevation made by the Pointer. *jE* offsets the contacts of the *jE* Follow-up. If the Pointer in the Director has his signal key closed, the clutch on the *jE* line is engaged. The *jE* Follow-up drives *jE* through ratio gearing producing *jEc*. *jEc* is the *Linear* Elevation *Rate* Correction which goes into the *jEc* Component Integrator in the Rate Control Computing Mechanism.

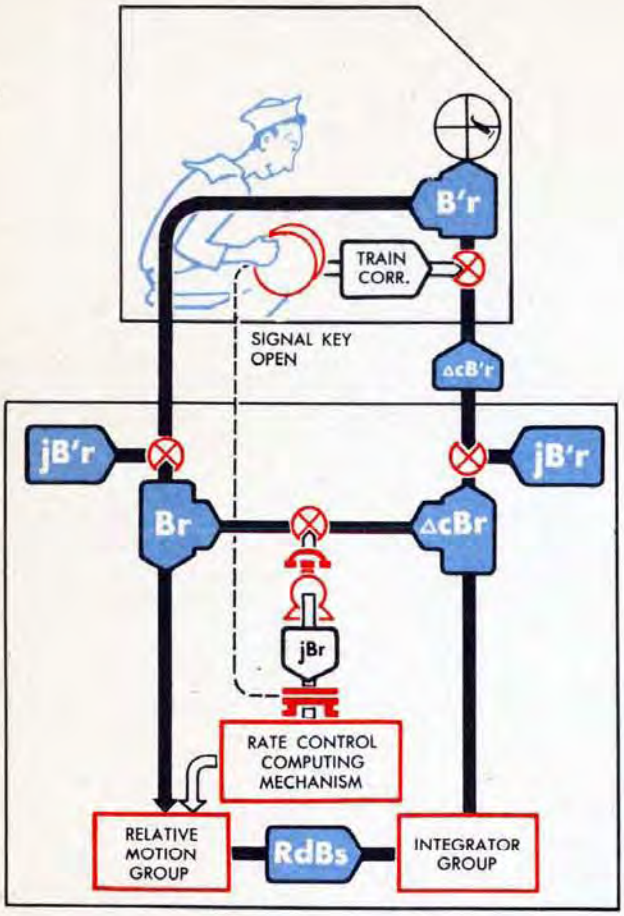
From this point on, the part played by *jEc* in the computation of corrections to Target Motion values is EXACTLY THE SAME AS IN SEMI-AUTOMATIC RATE CONTROL.

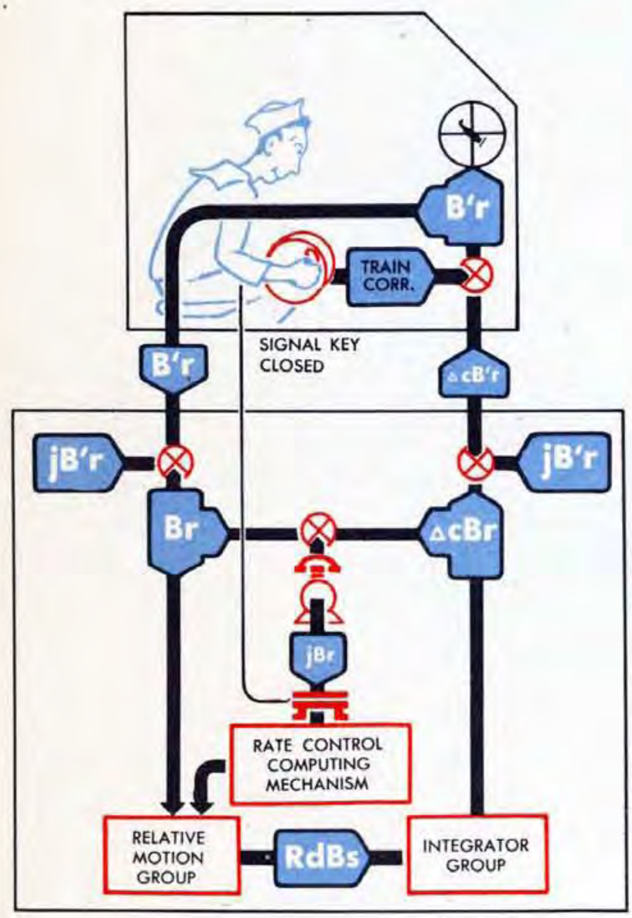
The Angular Elevation Correction, *jE*, is not only used to form Elevation Rate Correction, *jEc*, but is also driven back to differential D-38 where it is added to △*cE*. *jE* + △*cE* acts as response to the *jE* Follow-up and keeps the Generated Dial turning with the Observed Dial.

When the Pointer has his signal key closed, the signal flag near the Elevation Dials shows red, indicating that the clutch on the *jE* line is engaged.

Rotation of the Solution Indicator while the flag shows red indicates that Rate Corrections are being made. It shows that the Pointer is turning his handwheels and the *jE* line to the Rate Control Computing Mechanism is turning.

When the Solution Indicator stops turning, the Elevation part of the problem is solved. The Generated Changes of Director Elevation are being computed at a rate which keeps the sights on Target in elevation.





The trainer's job

Suppose that Generated Changes of Director Train, $\triangle cB'r$, are not keeping the Trainer's sight on the Target.

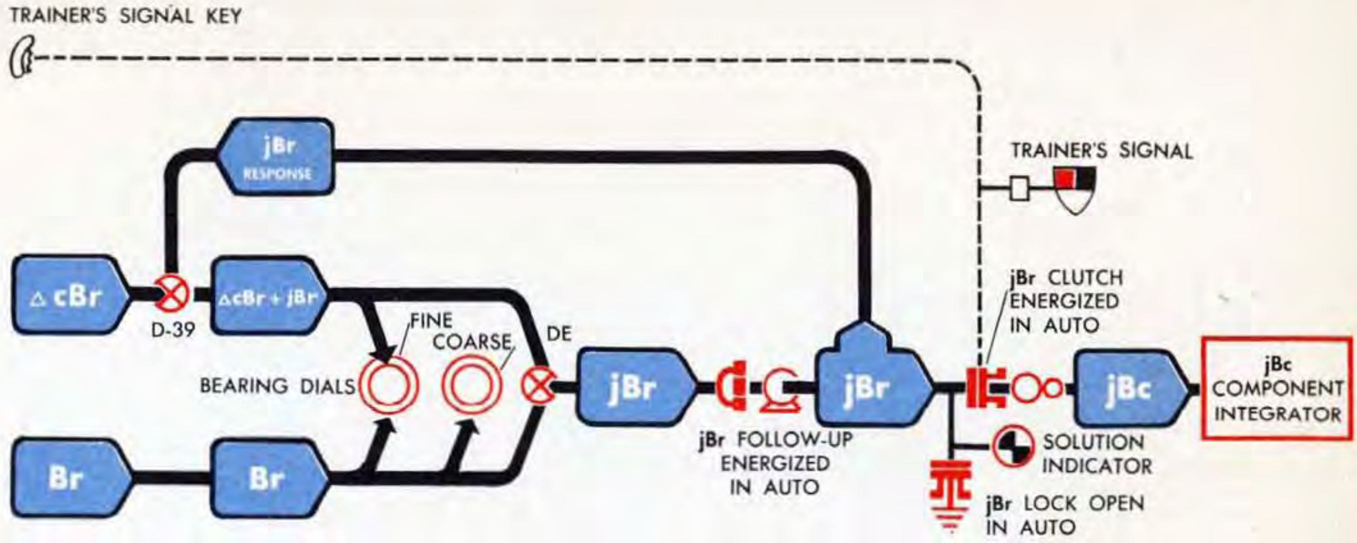
The Trainer's sight, driven by $\triangle cB'r$ from the Integrator Group in the Computer, is not centered on the Target and is steadily moving away from the Target. The value of $B'r$ going to the Computer is incorrect, and Br and Deflection Rate, $RdBs$, in the Computer are also incorrect.

The trainer turns his handwheels an amount to put the crosshair of his sight onto the Target. The values of $B'r$ and Br are now correct.

When the crosshair is on the Target, the Trainer presses his signal key, and continues to turn his handwheels to keep on the Target. By turning his handwheels he puts in a Train Correction which is added to $\triangle cB'r$ to *keep* the values of $B'r$ and Br correct. The Train Correction is referred to the horizontal plane by adding $jB'r$. It then exists in Br as a correction called jBr.

In the Rate Control Group, the changes of Br are continuously compared with $\triangle cBr$. The difference between $\triangle cBr$ and Br is the amount jBr, which offsets the contacts of the jBr Follow-up. When the Trainer's Signal Key is closed as he turns his handwheels, the clutch on the jBr line is engaged and the jBr Follow-up drives jBr into the Rate Control Computing Mechanism.

The Rate Control Computing Mechanism computes corrections to the inputs to the Relative Motion Group. Deflection Rate, $RdBs$, is corrected until the integrators generate $\triangle cB'r$ at a rate which keeps the Trainer's sight on the Target automatically without any Train Correction.



Rate-controlling bearing in auto

Observed Changes of Relative Target Bearing, *Br*, are compared with Generated Changes of Relative Target Bearing, △*cBr*, at differential DE in the Rate Control Group.

The difference between changes of *Br* and △*cBr* is the differential output, *jBr*. *jBr* is the *Angular* Correction to Generated Bearing made by the Trainer. *jBr* offsets the contacts of the *jBr* Follow-up. When the Trainer in the Director has his signal key closed, the clutch on the *jBr* line is engaged. The *jBr* Follow-up drives *jBr* through ratio gearing producing *jBc*. *jBc* is the *Linear* Deflection *Rate* Correction which goes into the *jBc* Component Integrator in the Rate Control Computing Mechanism.

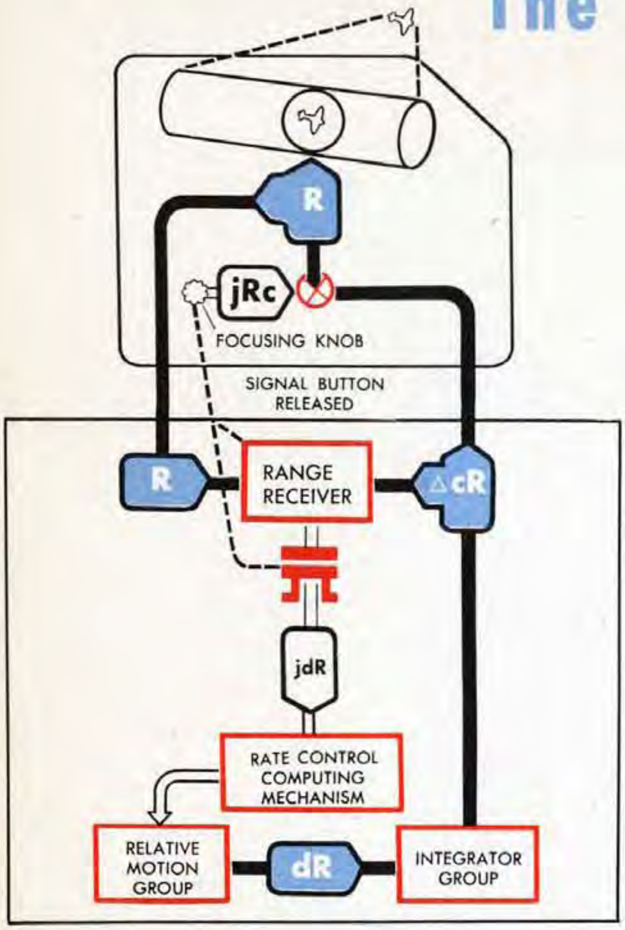
From this point on, the part played by *jBc* in the computation of corrections to Target Motion values is the same as in Semi-automatic Rate Control.

Besides producing Deflection Rate Correction, *jBc*, *jBr* is driven back to differential D-39, where it is added to △*cBr*. *jBr* + △*cBr* acts as response to the *jBr* Follow-up and also keeps the Generated Dial turning with the Observed Dial.

The Trainer's Signal Flag and the Solution Indicator at the Bearing Dials work in the same way as the flag and indicator at the Elevation Dials. When the signal flag shows red the Trainer has his signal key closed and the clutch on the *jBr* line is engaged. When the Solution Indicator is turning and the flag shows red, Deflection Rate Corrections are being made. The Trainer is turning his handwheels and the *jBr* line to the Rate Control Mechanism is turning.

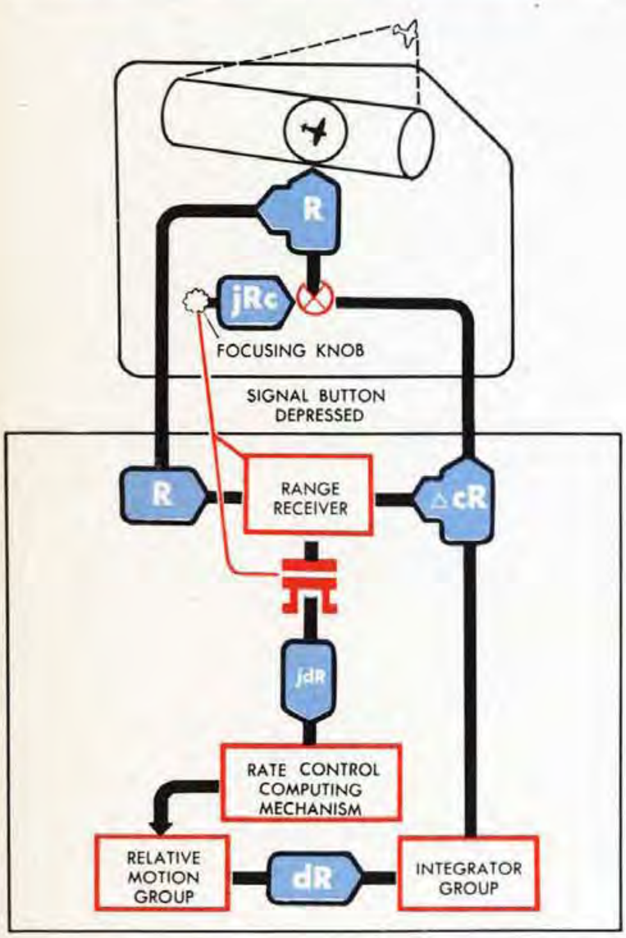
When the Solution Indicator stops turning, the Bearing part of the problem is solved, the Generated and Observed Relative Target Bearing Dials turn together, and Generated and Observed Bearing are changing at the same rate.

The range operator's job



Whenever Generated Changes of Range, $\triangle cR$, do not keep the Range Finder in focus, the $\triangle cR$ values are incorrect. When the Range Finder is out of focus the value of R going down to the computer is also incorrect.

To correct the value of R, the Range Operator turns his knob until the diamond field seems to be the same distance away as the Target. Once in focus, the Operator keeps his signal button depressed, as he corrects to *remain* in focus. The amount he turns his knob, jRc, is continuously added to $\triangle cR$ to keep the value of R correct.



In the Rate Control Group, the value of R is continuously being compared with cR. The difference between R and cR is equal to the amount jRc which the Range Operator is adding. This difference offsets the contacts of the jdR Motor. When the Range Operator's Signal Button is depressed, the clutch on the jdR line is engaged and the jdR Motor drives jdR into the Rate Control Computing Mechanism as a rate correction.

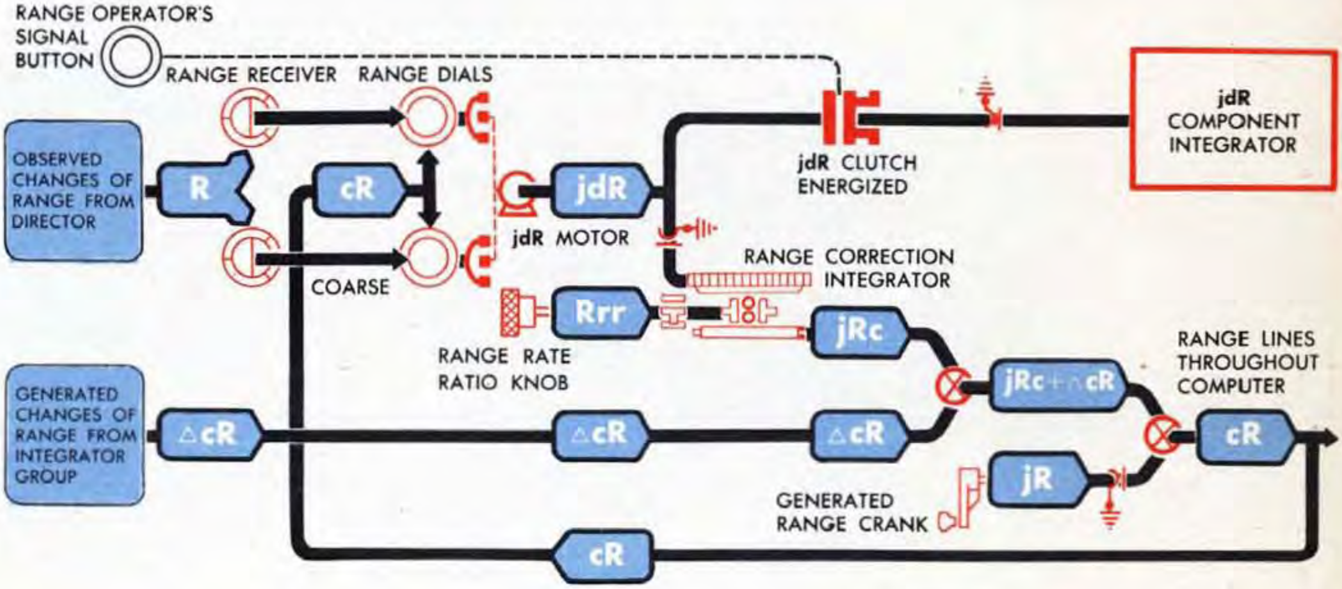
The Rate Control Computing Mechanism computes corrections to Sh, dH, and A, and sends corrected values of these quantities to the Relative Motion Group. These quantities are corrected until the value of Range Rate, dR, causes the Integrator Group to generate $\triangle cR$ at a rate which will keep the Range Finder in focus without help from the Range Operator. When dR is correct, R and cR change at the same rate and are equal. There is no difference between them when they are compared, and no jdR input is needed.

Rate-controlling range

In the Computer, Observed Range, *R*, is received electrically at the Range Receiver. At the Range Receiver contacts, *R* is compared with *cR*. When *R* and *cR* are not equal, the *jdR* Motor is energized whenever the Range Finder Signal Key is closed.

Even in FULL Automatic Rate Control, the amount of *jdR* feeding into the Rate Control Computing Mechanism is determined by the hand setting of the Range Rate Ratio Knob, which positions the carriage of the Range Correction Integrator. The disk of the Range Correction Integrator is turned by *jdR;* the integrator output is *jRc,* the linear correction to Generated Range, *cR*. The *jdR* Motor drives an amount, *jdR,* producing enough *linear* correction *jRc* to match *cR* with *R* at the Range Dials. When the Range Operator has his signal button depressed, the clutch on the *jdR* line is engaged. The *jdR* Motor drives *jdR* through the clutch and into the *jdR* Component Integrator in the Rate Control Computing Mechanism.

When *cR* and *R* are matched and are changing at the same rate, the Range Receiver contacts remain synchronized and the Range Dials turn together. *cR changes at a rate which keeps the Range Finder continuously focused correctly*. The Range part of the problem is solved.



The DOUBLE-SPEED RANGE RECEIVER

RANGE DIALS

OBSERVED RANGE DIALS

SEGMENTS AND DIALS DRIVEN BY cR

The Double-speed Range Receiver is located below the Range Dials. The coarse synchro motor is directly below the coarse Range Dials and the fine synchro motor directly below the fine Range Dials. Between each synchro motor and its dials is a contact assembly consisting of brushes, segments, and slip rings.

The synchro rotors are driven by Observed Range, *R*, which is transmitted electrically from the Director. The rotor of the coarse synchro is attached to the coarse Observed Range Dial. The rotor of the fine synchro is attached to the fine Observed Range Dial.

Here are the Observed Range Dials, removed from the Computer. Contact brush A and slip ring A are attached to the under side of the coarse dial. Trolley contact E and slip ring E are attached to the under side of the fine dial.

Here the Observed Dials have been removed to show the contact segments. Contact brush A on the coarse Observed Range Dial bears against segments B and C, and isolated contact D. Segments B and C, and isolated contact D, are attached to the coarse Generated Range Ring Dial, and are driven mechanically by Generated Range *cR*. Trolley contact E on the fine Observed Range Dial bears against segments F and G. Segments F and G are attached to the fine Generated Range Ring Dial and are also driven mechanically by Generated Range, *cR*.

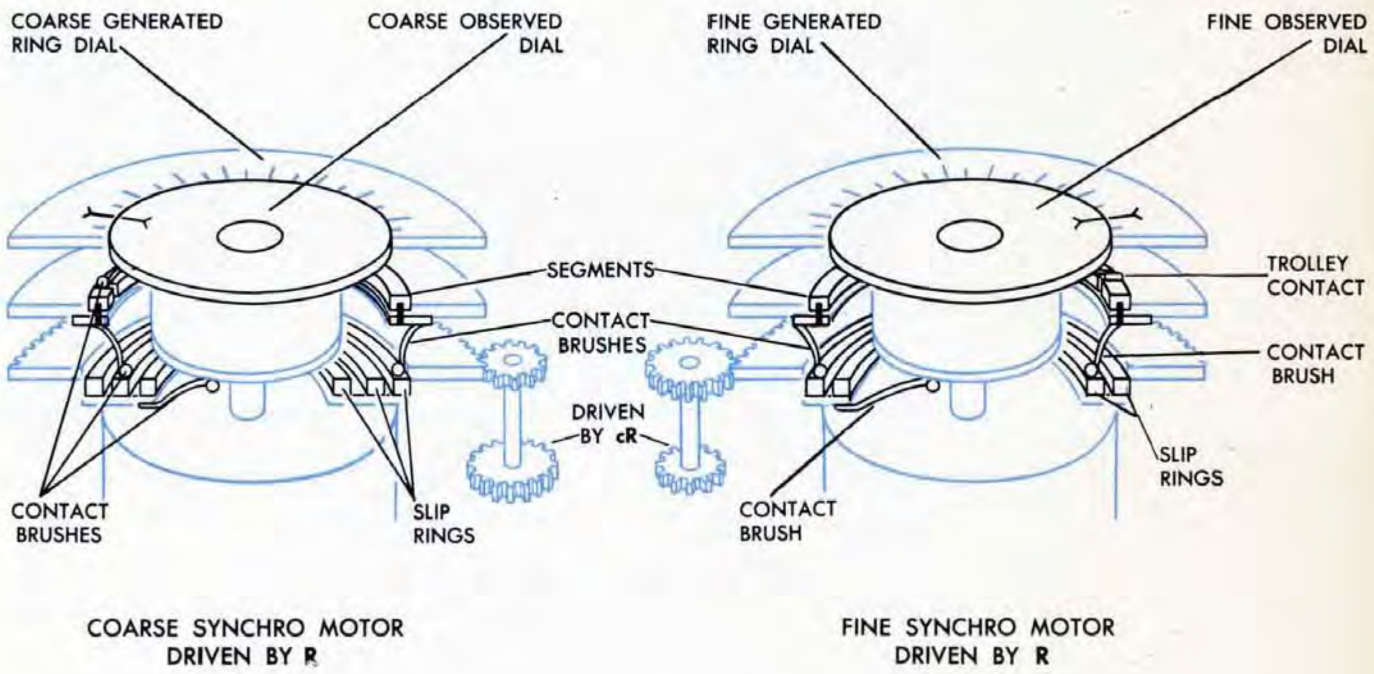
A contact brush is attached to the under side of each of the five segments. Each of these five contact brushes bears against one of the five slip rings shown here. Rings B, C, D, F and G are fastened to the unit mounting plate, and are connected by wires to the *jdR* Motor. Contact brushes X and Y are also fastened to the unit plate. Ring D of the coarse contacts is connected by a wire to brush Y. Brush Y bears against slip ring E on the fine Observed Range Dial, while brush X bears against slip ring A on the coarse Observed Range Dial.

While segments F and G and the fine Generated Range Dial revolve 36 times, segments B and C, isolated contact D, and the coarse Generated Range Dial, revolve only once. Trolley contact E and the fine Observed Range Dial revolve 36 times while brush A and the coarse Observed Range Dial revolve once.

The Range Receiver is like other double-speed receivers in that the rotors of its two synchro motors are driven by signals coming in electrically. It is unlike other double-speed receivers in that the follow-ups of most receivers drive an amount proportional to the signals on their rotors, *while the Range Receiver motor drives an amount proportional to the DIFFERENCE between R and cR.*

As in the case of all double-speed receivers, the coarse and fine Range Receiver synchro motors operate coarse and fine contacts which control the action of a servo motor. The servo motor controlled by the Range Receiver synchros is the *jdR* Motor. When a target is sighted and tracking first begins, the difference between Observed Range, *R,* and Generated Range, *cR,* may be large. When this is the case, the coarse contacts are in control of the *jdR* Motor. However, as soon as the coarse contacts are synchronized, the fine contacts are in control of the *jdR* Motor.

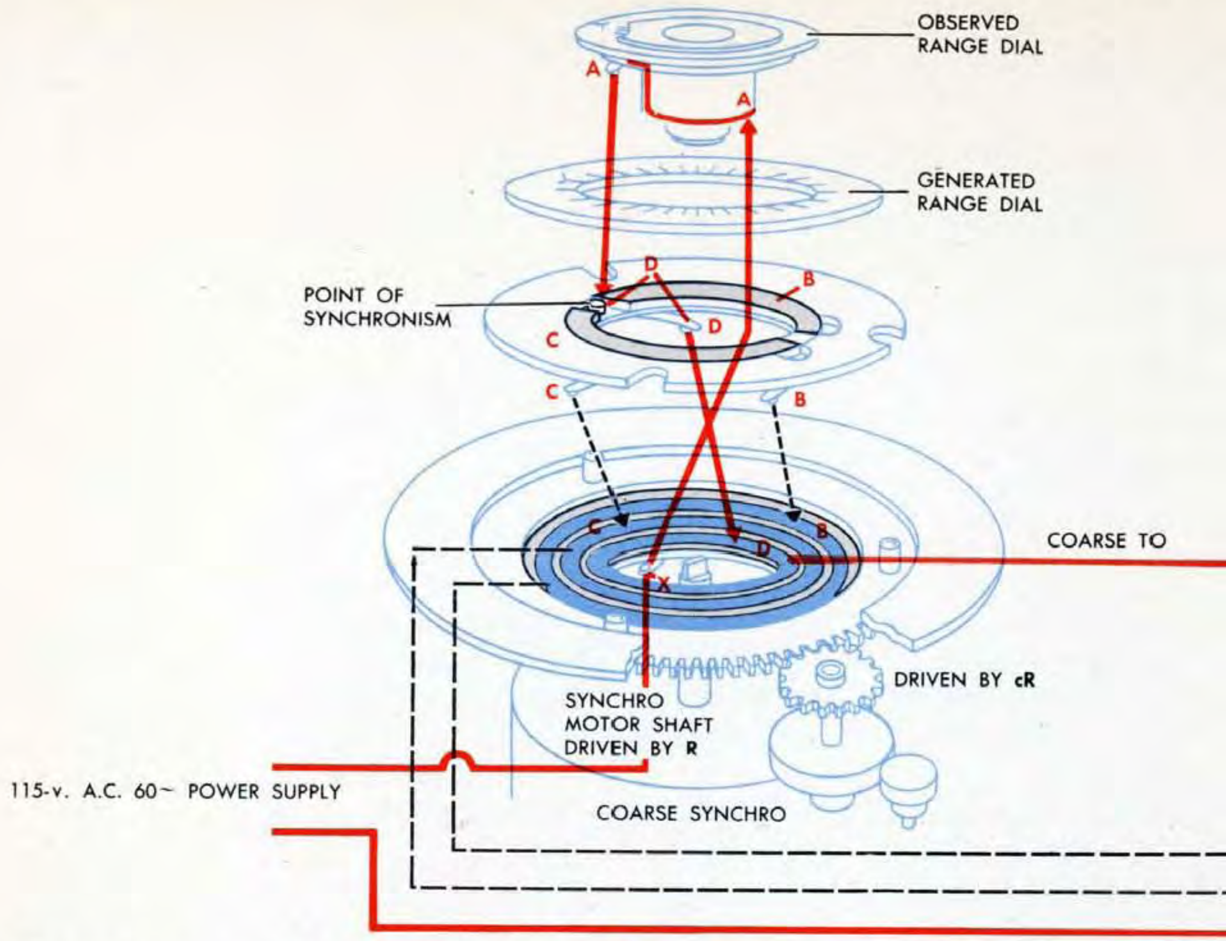
This sketch shows the position of the parts of the Double-speed Range Receiver:



The Observed Range Dials are attached to the synchro motors and are driven by *R.*

The segments are attached to the ring dials and are driven by *cR.*

The slip rings are attached to the unit mounting plate and are connected electrically to the *jdR* Motor.



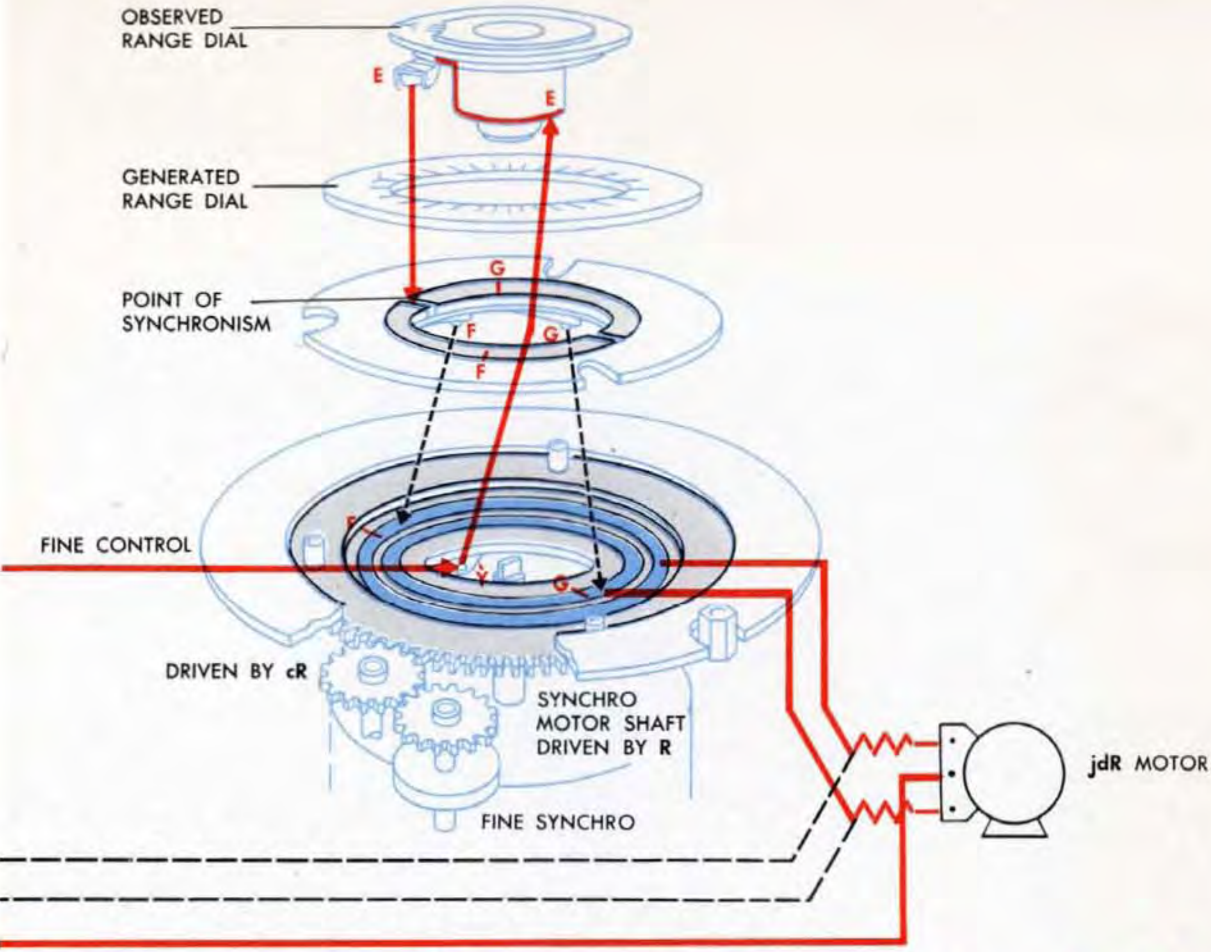
The Coarse Control Electrical Circuits

Slip ring A and contact brush A are fastened to the under side of the Observed Range Dial. Slip ring A is in contact with brush X which is connected to one side of the power supply. Contact brush A touches one of the three segments, B, C, or D. Segments B, C, and D are rotated mechanically by Generated Range, *cR*.

When contact brush A touches segment B, the electrical circuit to the *jdR* Motor is completed through segment B, contact brush B, and ring B, energizing the *jdR* Motor and driving it in one direction.

When contact brush A touches segment C, the electrical circuit to the *jdR* Motor is completed through segment C, contact brush C, and ring C, energizing the *jdR* Motor and driving it in the opposite direction.

When contact brush A touches the isolated contact D as shown in this diagram, the electrical circuit to contact brush Y on the *fine* contacts is completed through the isolated contact D, contact brush D, and ring D.



The Fine Control Electrical Circuits

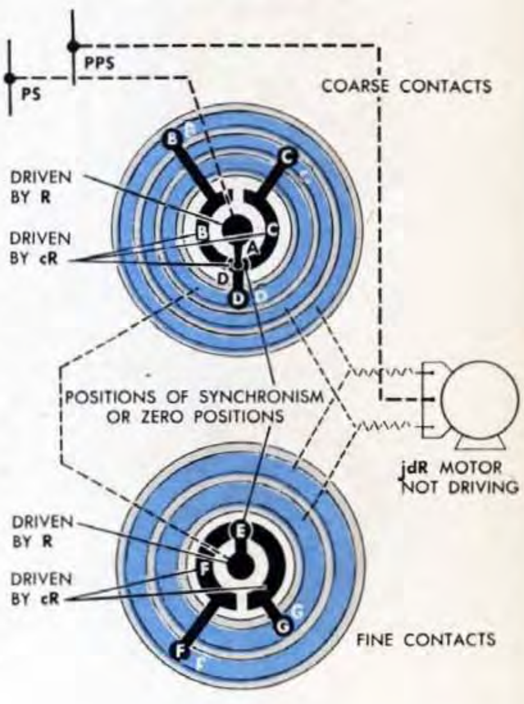
The fine contacts are in control of the *jdR* Motor when the electrical circuit from the coarse contacts is completed to trolley contact E. On the fine contacts, trolley contact E and slip ring E are fastened to the under side of the Observed Range Dial. Slip ring E is in contact with brush Y which is connected to the power supply through the coarse contacts. Trolley contact E touches one of the two segments, F or G. Segments F and G are rotated mechanically by Generated Range, *cR*.

When trolley contact E touches segment F, the electrical circuit to the *jdR* Motor is completed through segment F, contact brush F, and ring F, driving the motor in one direction.

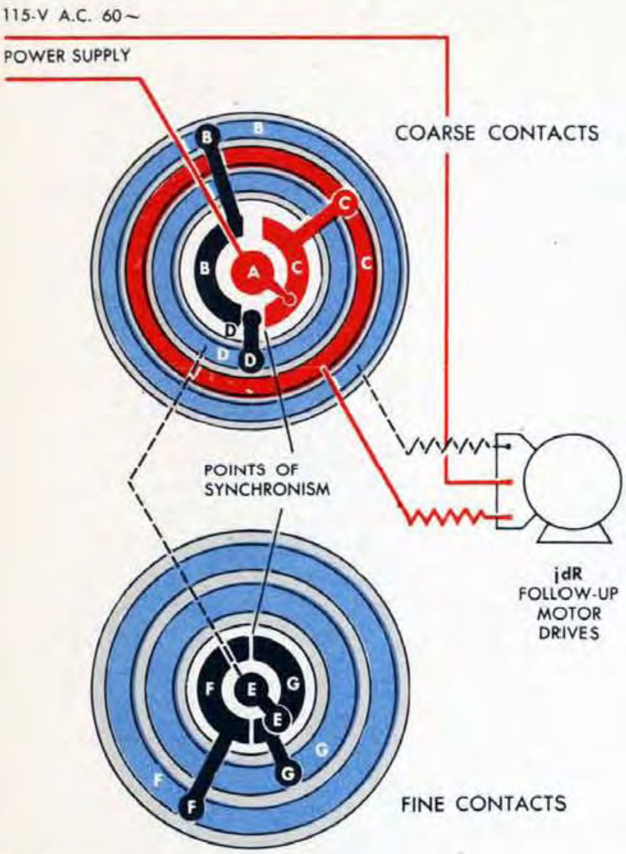
When trolley contact E touches segment G, the electrical circuit to the *jdR* Motor is completed through segment G, contact brush G, and ring G, and the motor drives in the opposite direction.

In the sketch above, trolley contact E is at the point of synchronism, touching both segments F and G. The *jdR* Motor is energized to drive in both directions at once and therefore does not drive at all. As long as trolley contact E remains at the point of synchronism, Observed Range, *R*, and Generated Range, *cR*, are equal.

The electrical circuit to the *jdR* Motor is always completed through the Range Rate Control Switch and the Range Finder Signal Button.

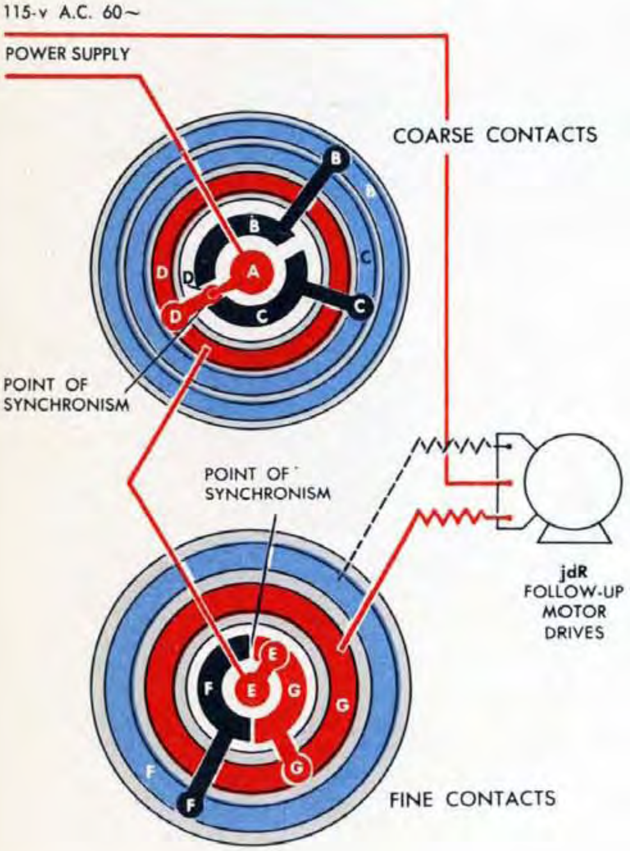


When the COARSE Contacts are in control



The coarse contacts of the Double-speed Range Receiver control the *jdR* Motor when the difference between *R* and *cR* is greater than 550 yards; otherwise the fine contacts are in control.

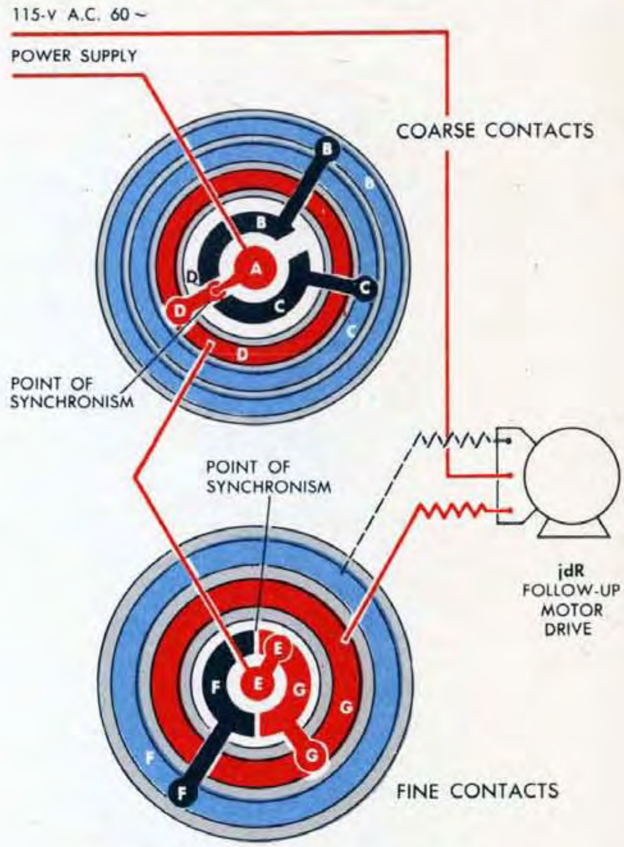
At the beginning of tracking, suppose that *R* is much greater than *cR*. Contact brush A on the coarse contacts would be off its point of synchronism on isolated contact D and on segment C, completing the circuit to the *jdR* Motor through segment C, contact brush C, and ring C. The *jdR* Motor is energized and drives the disk of the Range Correction Integrator, producing Linear Correction, *jRc*, and increasing the linear value of *cR*. *jdR* also feeds into the *jdR* Component Integrator, causing a range *rate* correction. Isolated contact D is driven counterclockwise toward its point of synchronism with contact brush A.



Now *R* is only slightly greater than *cR*. Isolated contact D has reached its point of synchronism, touching contact brush A.

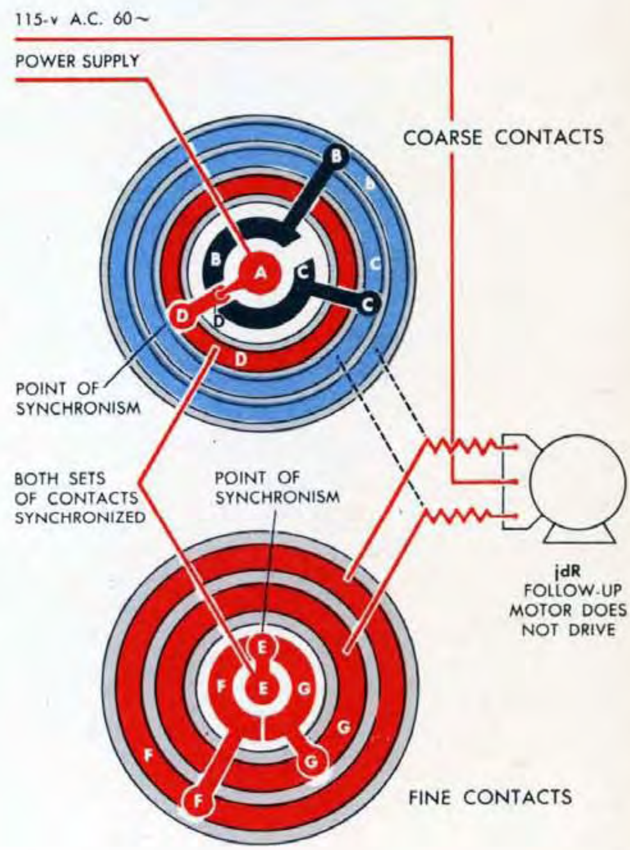
Now the electrical circuit is completed through contact brush D and ring D of the coarse contacts to trolley contact E of the fine contacts, and the fine contacts are in control of the *jdR* Motor.

When the FINE Contacts are in control

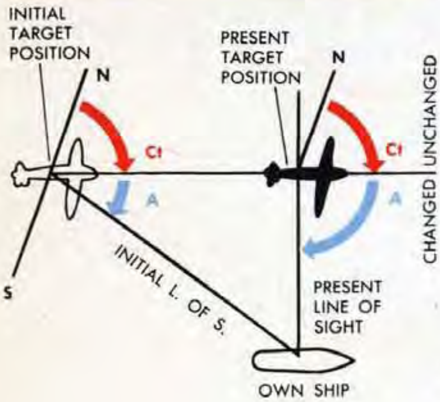


Since *R* is still slightly greater than *cR*, the point of synchronism will be counterclockwise from trolley contact E. Now the electrical circuit to the *jdR* Motor is completed through segment G, contact brush G, and ring G. Therefore the *jdR* Motor continues to drive segments F and G clockwise to bring the point of synchronism under trolley contact E. This will make *cR* equal *R*.

If *R* had been slightly smaller than *cR*, the point of synchronism would have been clockwise from trolley contact E. The electrical circuit to the *jdR* Motor would have been completed through segment *F*, contact brush F, and ring F, and the *jdR* Motor would have been driven in the *opposite* direction, *decreasing* the value of *cR*.



When *R* and *cR* are equal and are changing at the same rate, trolley contact E is at the point of synchronism, touching both segments F and G. The *jdR* Motor is energized to drive equally in both directions at once and therefore does not drive at all.



The TARGET COURSE INDICATOR

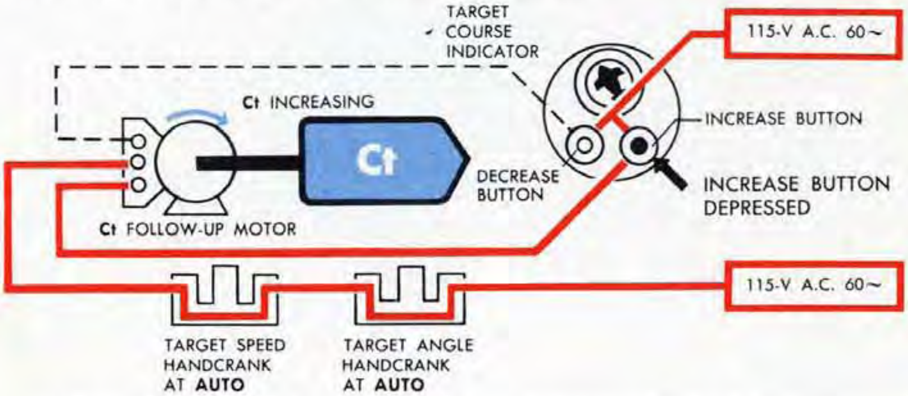
This is a Target Course Indicator. It is fastened to the side of the Star Shell Computer on top of the Computer Mark 1.

Target Angle, *A*, changes continuously as the relative position of Own Ship and Target changes, but Target Course, *Ct*, is measured from *North*, and therefore remains constant as long as the direction of motion of the Target does not change. For this reason and others, *Ct* is used to estimate the direction of motion of the Target.

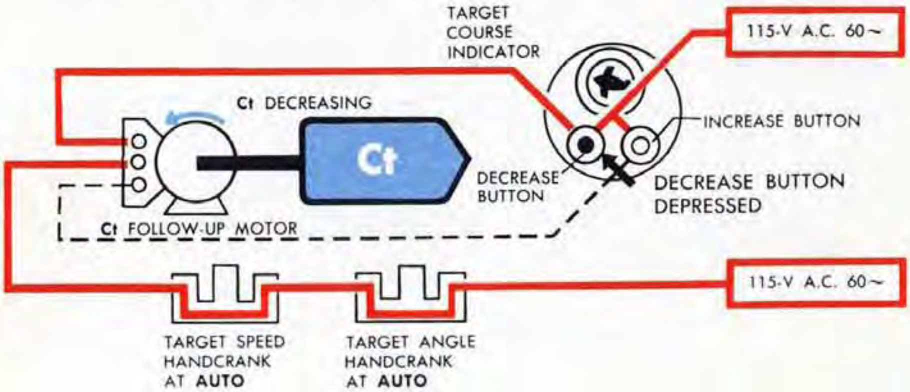
Corrections to Target Course, *Ct*, may be made faster by using the Target Course Indicator than by using the Target Angle Handcrank.

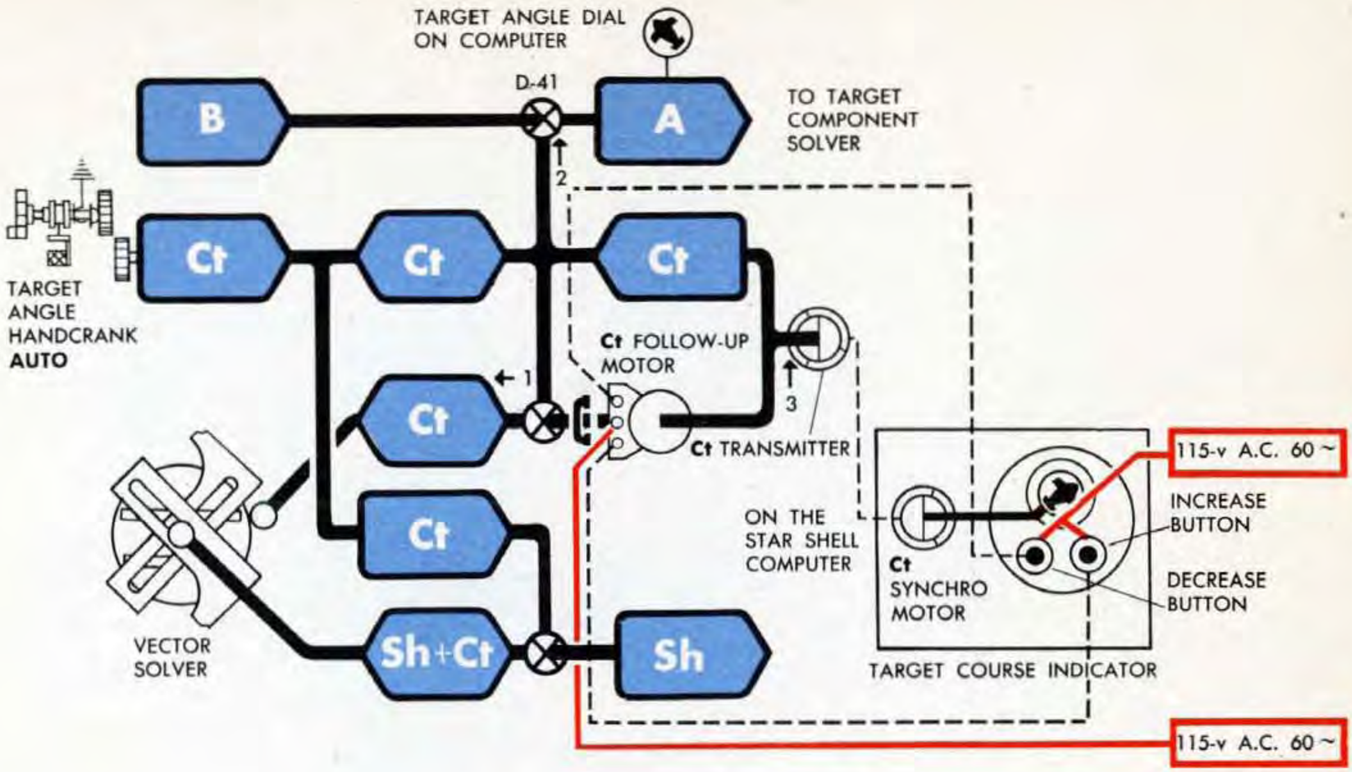
The Target Course Indicator contains a dial, a synchro motor, an INCREASE Button, and a DECREASE Button. Target Course, *Ct*, is read on the graduated index plate, opposite the bow of the Target on the dial.

The INCREASE and DECREASE Buttons on the Target Course Indicator are connected electrically through relays to the *Ct* Follow-up Motor in the Rate Control Group in the Computer. When the INCREASE Button is depressed and the Target Speed and Target Angle Handcranks are at AUTO, the *Ct* Follow-up Motor is energized and drives in the direction *to increase the value of Ct in the Computer.*



When the DECREASE Button is depressed, the *Ct* Follow-up Motor is energized to drive in the *opposite* direction, *decreasing the value of Ct in the Computer.*





A single-speed transmitter is connected to the *Ct* shaft line. Whenever the *Ct* Follow-up Motor drives, the increase or decrease in *Ct* repositions the rotor of the *Ct* Transmitter. This *Ct* Transmitter is connected electrically to the synchro motor in the Target Course Indicator.

As soon as the rotor of the *Ct* Transmitter is moved to a new position, the increase or decrease in the value of *Ct* is transmitted to the synchro motor in the Target Course Indicator. The rotor moves to a new position corresponding to the new position of the *Ct* Transmitter. Since the dial of the Target Course Indicator is attached to the synchro rotor, the dial is moved to the new position and the value of *Ct* in the Computer can always be read on the Target Course Indicator Dial.

The Computer Operators can correct Target Course, *Ct*, in the Computer by pressing the INCREASE or DECREASE Button on the Target Course Indicator. These buttons operate relays which control the direction of rotation of the *Ct* Follow-up Motor. As long as either button is depressed, the *Ct* Follow-up Motor will drive new values of *Ct* to three mechanisms:

1 To the Vector Solver, repositioning the vector gear.
2 To differential D-41 where *Ct* is subtracted from $B + 180°$, giving a corrected value of *A*.
3 To the *Ct* Transmitter, to be transmitted back to the Target Course Indicator.

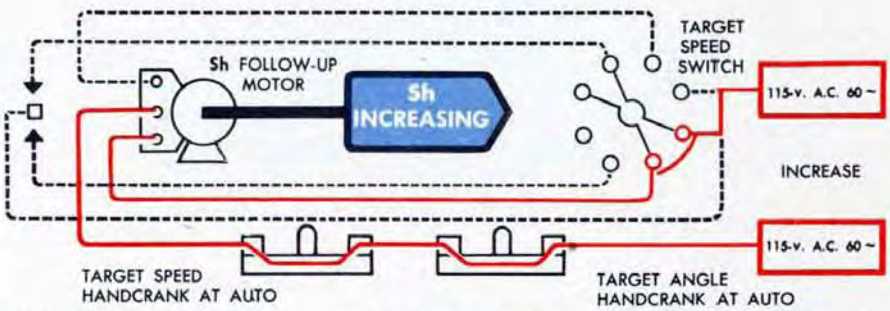
The TARGET SPEED SWITCH

This is the Target Speed Switch. It is located on the top of the Computer Mark 1 at the front left corner.

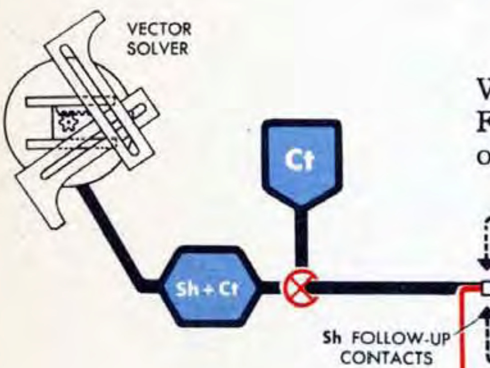
The Target Speed Switch has two uses:

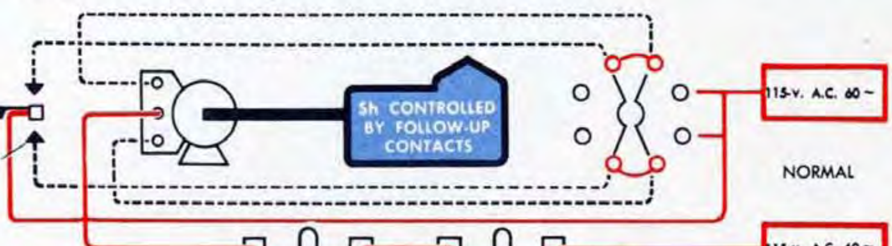
1. It can be used instead of the Target Speed Handcrank for putting initial or corrective values of *Sh* into the Computer quickly.
2. It can be used to run *Sh* to zero in preparing the Computer for a dive attack.

The Target Speed Switch energizes the *Sh* Follow-up Motor only when both the Target Speed and Target Angle Handcranks are at AUTO. The Switch has three positions: INCREASE, DIVE ATTACK, and NORMAL.

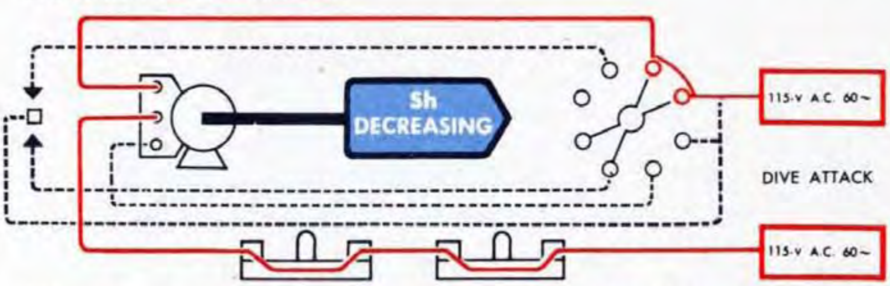


When the Target Speed Switch is held at INCREASE, the *Sh* Follow-up Motor drives in the direction to *increase* the value of *Sh* in the Computer.





When the Target Speed Switch is at NORMAL, the *Sh* Follow-up Motor is energized by the follow-up contacts on the *Sh* line from the Vector Solver.

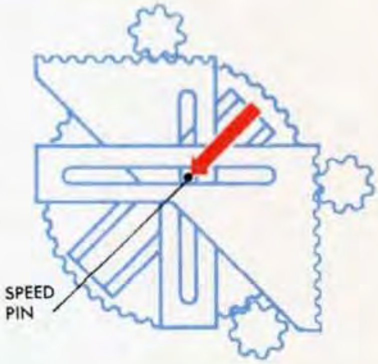


When the Target Speed Switch is at DIVE ATTACK, the *Sh* Follow-up Motor drives in the direction to *decrease* the value of *Sh* in the Computer.

A detent holds the switch at DIVE ATTACK, allowing the Operator to shift the Range Rate/Diving Speed Handcrank to HAND and crank in DIVING SPEED while *Sh* is running to zero.

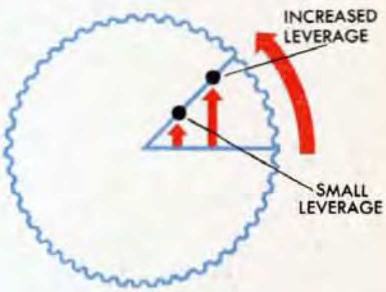
Making large changes in **target speed**

To put a large change of Target Speed into the Computer quickly, the Computer Operator holds the Target Speed Switch at INCREASE or DIVE ATTACK and watches the Target Speed Counter until the desired value appears. Holding the switch at DIVE ATTACK will rapidly *decrease* the Target Speed value, and holding the switch at INCREASE will rapidly *increase* the Target Speed value in the Computer.



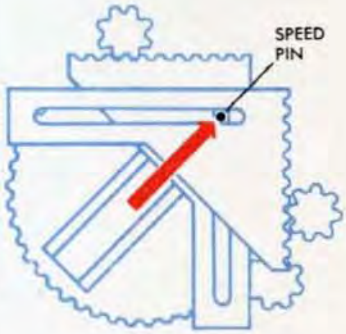
Making large changes in **target angle**

When a large change in Target Angle is reported, the Computer Operator shifts the lever of the Target Angle Handcrank to HAND and sets the new value of Target Angle onto the Target Dial. If a large change occurs in Target Angle but is not reported and set in by hand, the Vector Solver input racks will attempt to move the vector gear to its new position. Under these circumstances the racks may push the speed pin to the center of the vector gear instead of rotating the vector gear. With the speed pin at or near the center of the vector gear, the Vector Solver racks cannot turn the vector gear because the leverage is too small.

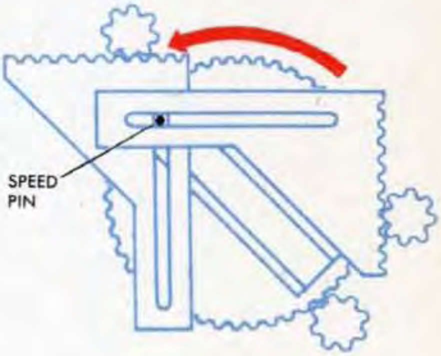


Assisting the vector solver when the speed pin runs to the center

When the speed pin in the Vector Solver runs to the center of the vector gear, the Computer Operator holds the Target Speed Switch at INCREASE. This increases the value of Target Speed in the Computer, running the speed pin away from the center of the vector gear, and holding it there, until the racks can turn the vector gear to its correct position.



If the position of the vector gear is 180° in error, it will be necessary to rotate the vector gear by turning the Target Angle Handcrank until the Vector Solver racks are again able to position the vector gear.



Dive attack

When preparing the Computer for Special Dive Attack Procedure, the Target Speed Switch is held at DIVE ATTACK until the value of *Sh* is zero.

THE CONTROL SWITCH

This is the Control Switch. It is located on the top of the Computer Mark 1 at the front righthand corner.

The Control Switch controls the electrical circuits to these mechanisms:

The *jE* Follow-up

The *jBr* Follow-up

The *jE* Clutch and Lock

The *jBr* Clutch and Lock

The two *B'r* Follow-up Motors

The Control Switch has three positions: AUTO, SEMI-AUTO and LOCAL.

Control Switch at AUTO

When the Control Switch is turned to AUTO and the Target Speed Handcrank is at AUTO, for Automatic Rate Control, these electrical connections are made:

1 The *jE* and *jBr* Follow-ups are connected to the power supply.

2 The *jE* Clutch can be energized by the Pointer's Signal Key.

3 The *jBr* Clutch can be energized by the Trainer's Signal Key.

4 The Director Train Receiver is connected to the power supply and the Director Train Receiver contacts control the two *B'r* Follow-up Motors.

5 The *jE* and *jBr* locks are de-energized and spring open, allowing the *jE* and *jBr* Follow-ups to drive their lines.

The Pointer's Signal Key

Whenever the Pointer's Signal Key is depressed, the Pointer's Signal at the Computer is energized and the signal changes from black to red. With the Control Switch at AUTO and the Target Speed Handcrank at AUTO, depressing the Pointer's Signal Key also energizes and engages the *jE* Clutch.

The Trainer's Signal Key

Whenever the Trainer's Signal Key is depressed, the Trainer's Signal at the Computer is energized and the signal changes from black to red. With the Control Switch at AUTO and the Target Speed Handcrank at AUTO, depressing the Trainer's Signal Key also energizes and engages the *jBr* Clutch.

Control Switch at SEMI-AUTO

When the Control Switch is turned from AUTO to SEMI-AUTO, for Semi-automatic and Manual Rate Control, these electrical changes are made:

1 The *jE* and *jBr* Follow-ups are disconnected from the power supply.

2 The *jE* Clutch can no longer be energized by the Pointer's Signal Key.

3 The *jBr* Clutch can no longer be energized by the Trainer's Signal Key.

4 The Director Train Receiver remains connected to the power supply and still controls the contacts of the two *B'r* Follow-up Motors.

5 The *jE* and *jBr* Locks are connected to the power supply.

When the *jE* and *jBr* Locks are energized, the jaws engage and lock the shaft lines from the *jE* and *jBr* Follow-up Motors.

Control Switch at LOCAL

When the Control Switch is turned from SEMI-AUTO to LOCAL, for Local Control, these electrical changes are made:

1 The Director Train Receiver is disconnected from the power supply.

2 The Local Control Contacts are connected to the power supply and control the two *B'r* Follow-up Motors.

The *jE* and *jBr* Locks remain energized and locked.

The RANGE RATE CONTROL SWITCH

This is the Range Rate Control Switch. It is located on top of the Computer Mark 1, to the left of the Range Dials.

The Range Rate Control Switch controls the electrical circuits to the *jdR* Motor and the *jdR* Clutch. The *jdR* Motor is the Range Receiver servo.

The switch has two positions: AUTO and MANUAL

AUTO is used for Automatic Range Rate Control.

MANUAL is used for Semi-automatic and Manual Rate Control and for Local Control.

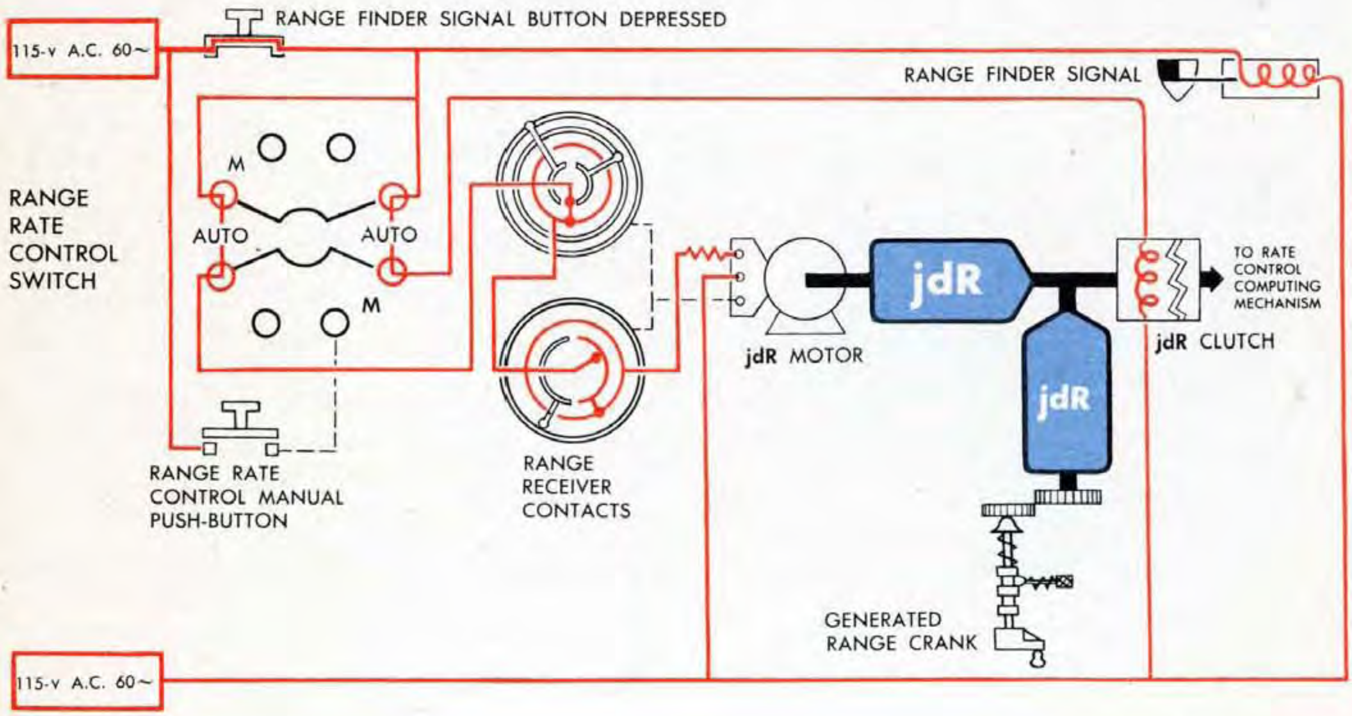
When the RANGE RATE CONTROL SWITCH is turned to AUTO

When the Range Rate Control Switch is turned to AUTO, two electrical circuits are completed whenever the Range Operator has his signal button depressed.

1 The Range Receiver contacts are connected to the power supply.

2 The *jdR* Clutch is connected to the power supply and is therefore engaged.

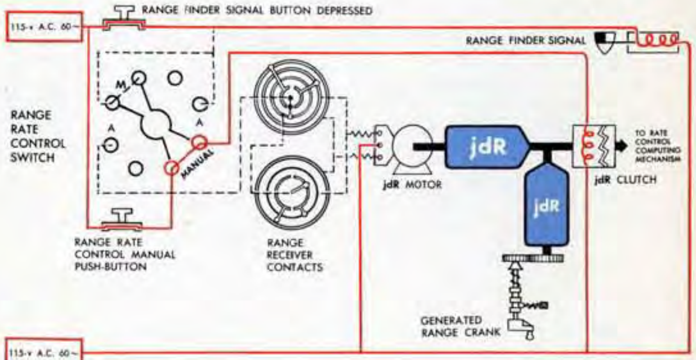
Whenever the Range Operator depresses his signal button, the Range Finder Signal near the Range Dials changes from black to white.

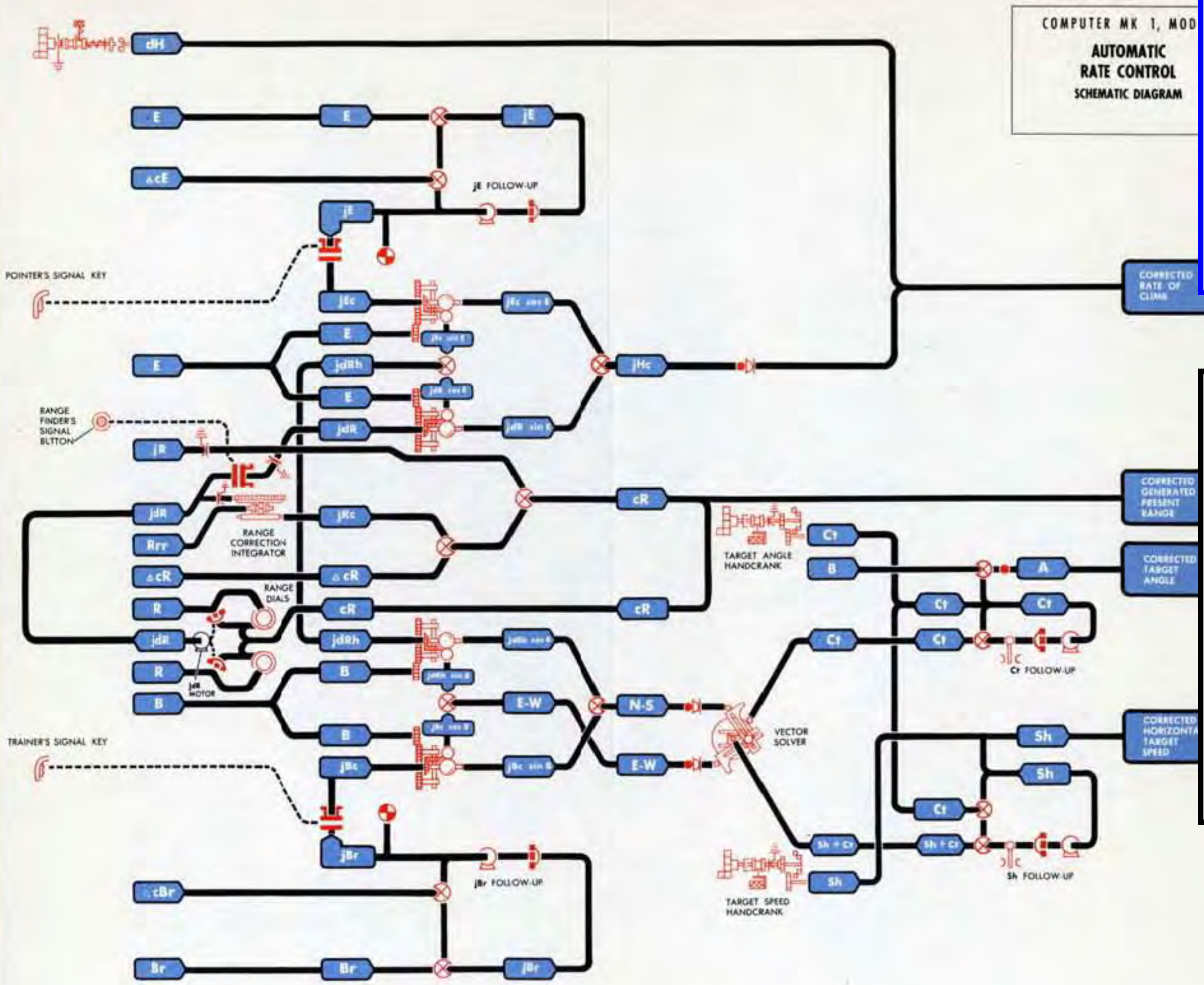


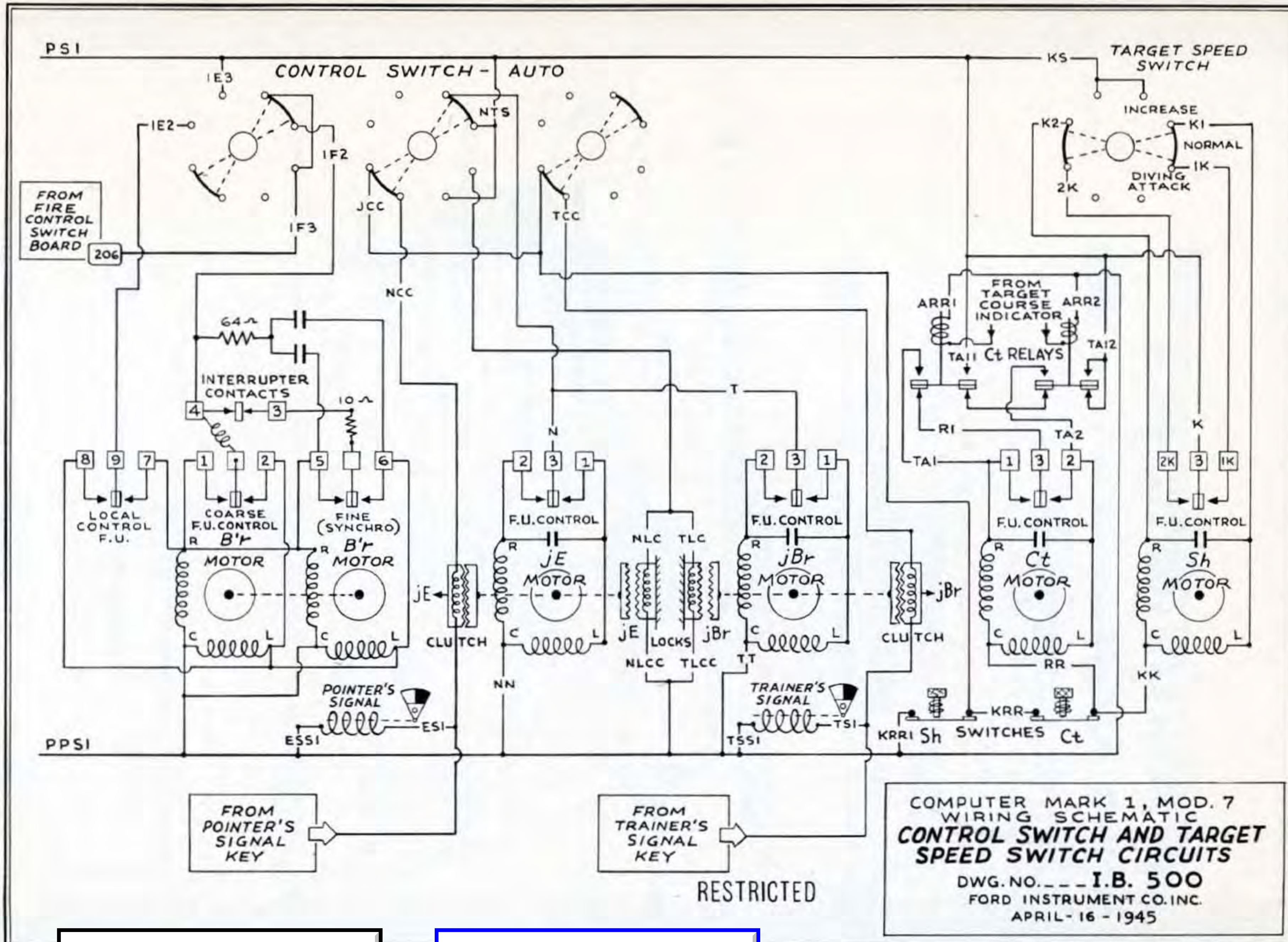
When the RANGE RATE CONTROL SWITCH is turned to MANUAL

When the Range Rate Control Switch is turned to MANUAL and the Range Rate Control Manual Push-button is depressed, the circuit to the *jdR* Clutch is completed, engaging the clutch. When the clutch is engaged, *jdR* Rate Corrections can be put into the Computer by hand, by turning the Generated Range Crank in its IN position.

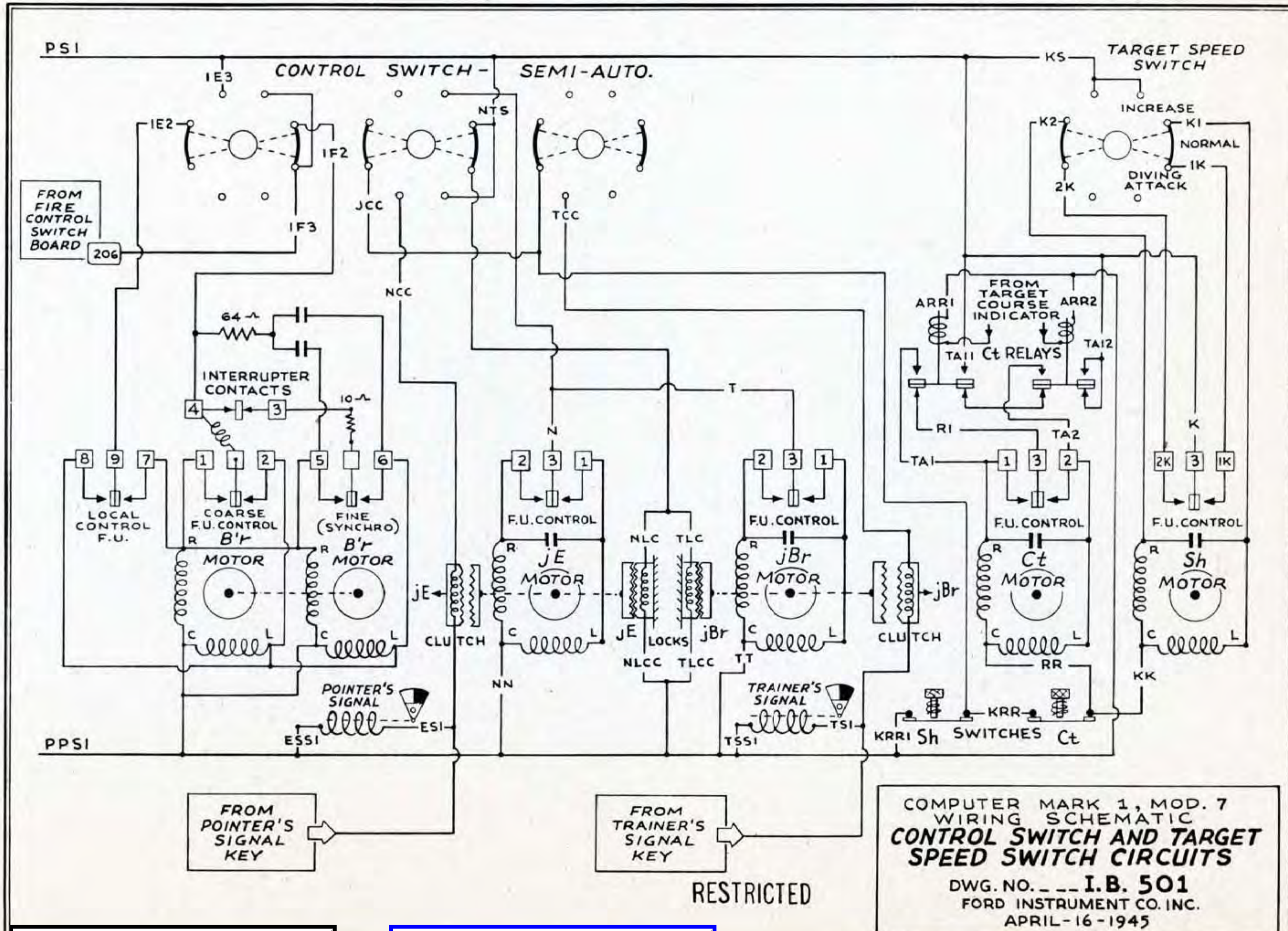
The circuit to the Range Finder Signal is completed whenever the Range Finder Signal Button is depressed.



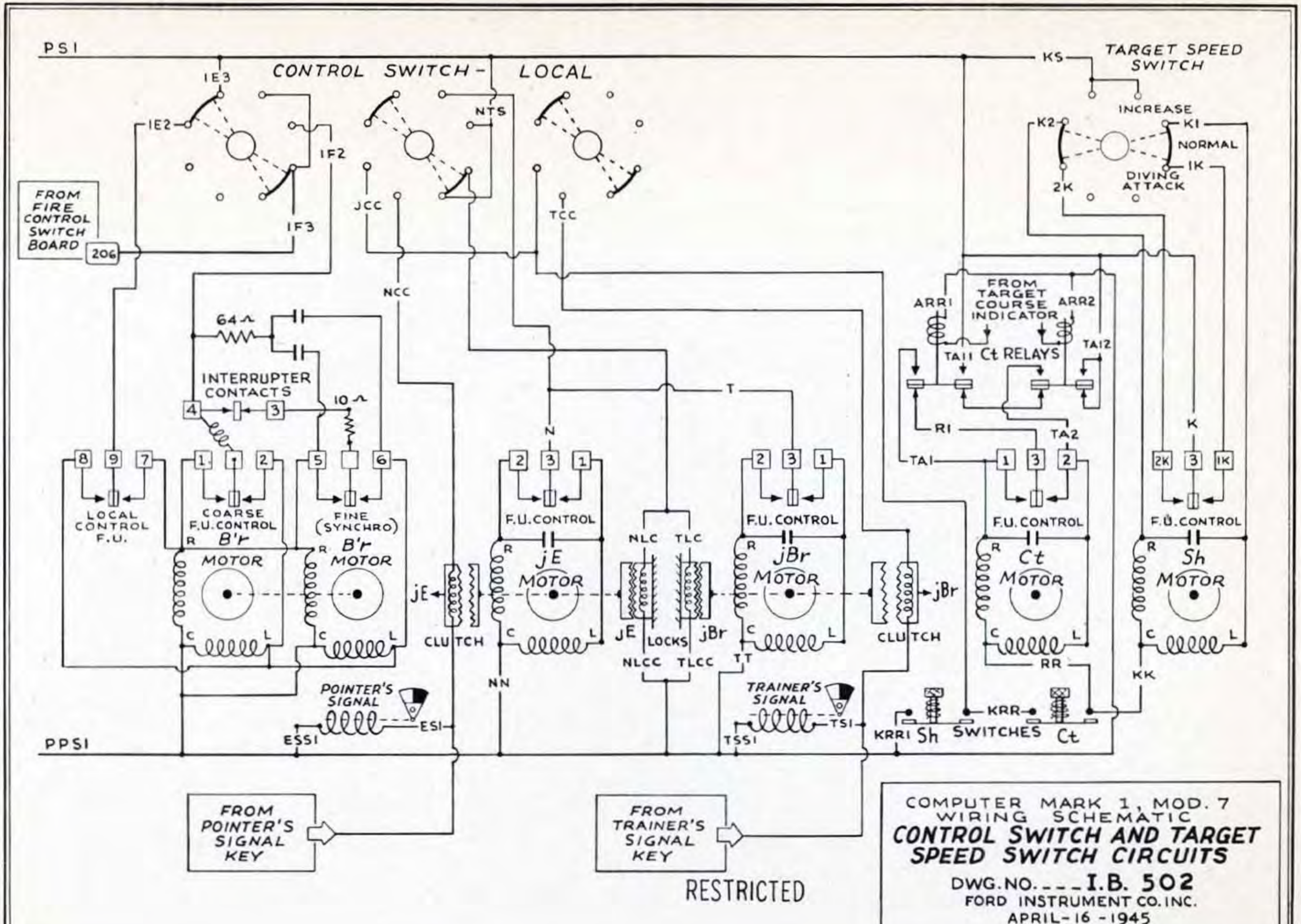




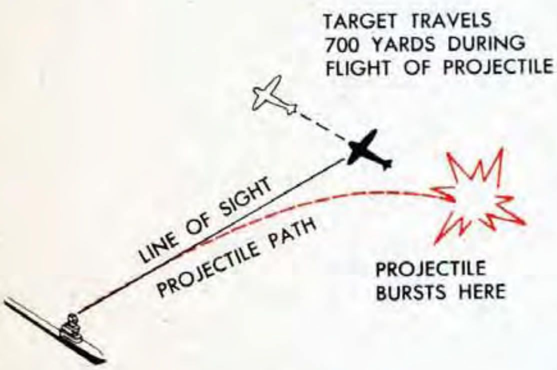
COMPUTER MARK 1, MOD. 7
WIRING SCHEMATIC
CONTROL SWITCH AND TARGET SPEED SWITCH CIRCUITS
DWG. NO.___I.B. 500
FORD INSTRUMENT CO. INC.
APRIL - 16 - 1945

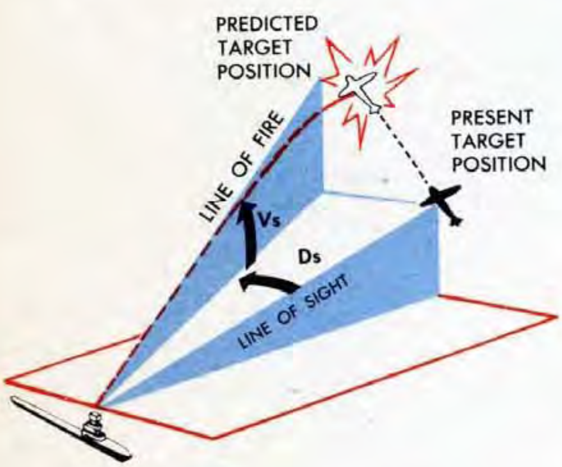


Gene Slover's US Navy Pages
Quick Reference Index


PSI
CONTROL SWITCH - LOCAL
IE3
IE2
IF2
IF3
NTS
JCC
TCC
NCC
FROM FIRE CONTROL SWITCH BOARD
206
TARGET SPEED SWITCH
KS
INCREASE
NORMAL
DIVING ATTACK
K2
K1
1K
2K
64 ~
10 ~
INTERRUPTER CONTACTS
N
T
K
FROM TARGET COURSE INDICATOR
ARR1
ARR2
TA11
Ct RELAYS
TA12
R1
TA2
TA1
LOCAL CONTROL F.U.
COARSE F.U. CONTROL
B'r
FINE (SYNCHRO)
B'r
MOTOR
MOTOR
F.U. CONTROL
jE
MOTOR
NLC
TLC
LOCKS
NLCC
TLCC
F.U. CONTROL
jBr
MOTOR
F.U. CONTROL
Ct
MOTOR
F.U. CONTROL
Sh
MOTOR
CLUTCH
CLUTCH
jE
jBr
NN
TT
RR
KK
POINTER'S SIGNAL
ESSI
ESI
TRAINER'S SIGNAL
TSSI
TSI
KRR
KRRI
Sh SWITCHES Ct
PPSI
FROM POINTER'S SIGNAL KEY
FROM TRAINER'S SIGNAL KEY
RESTRICTED
COMPUTER MARK 1, MOD. 7
WIRING SCHEMATIC
CONTROL SWITCH AND TARGET SPEED SWITCH CIRCUITS
DWG. NO. --- I.B. 502
FORD INSTRUMENT CO. INC.
APRIL-16-1945

THE PREDICTION SECTION





NOTE:

Several quantities in the Prediction Section contain a prime, ('), after the symbols, such as *Rt'*. A prime in the Prediction Section indicates that the computed quantity is not the true value defined by the symbols but is the symbol value plus an unwanted quantity introduced for design reasons. In each case, the unwanted quantity is removed mechanically in later computations. In all other sections of the Computer Mark 1, the presence of a prime in a symbol indicates that the quantity is measured in relation to the deck plane.

If projectiles could travel in a straight line at the impossible speed of several thousand miles per second, a Prediction Section would not be needed. The guns could be aimed and fired directly at any moving target.

But projectiles neither travel in a straight line, nor at several thousand miles per second. Even at the short range of 3000 yards, the projectile of a 5-inch gun takes about 4½ seconds to reach the Target. During the 4½ seconds, an air target traveling at 300 knots could have moved more than 700 yards, well out of danger of the burst of the projectile.

The Prediction Section establishes a Line of Fire along which the guns must point in order for the projectiles to hit the moving Target, and a fuze setting time such that the projectiles will burst close to the Target.

The Line of Fire is established by two lead angles, one in Elevation and one in Deflection. The lead angles are the angles by which the gun must be aimed ahead of, or lead, the Target to allow for these factors:

1. The movement of Target and Ship during flight of the projectile.
2. The curvature of the trajectory of the projectile due to Gravity and Drift.
3. The effect of Wind and Changes in Initial Velocity of the projectile.

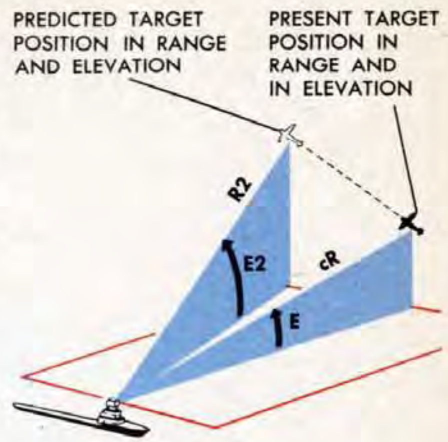
The lead angle in Elevation is called Sight Angle, *Vs*. Sight Angle, *Vs*, is the difference between the Elevation of the Line of Sight above the horizontal and the Elevation of the Line of Fire above the horizontal.

The lead angle in Deflection is called Sight Deflection, *Ds*. Sight Deflection, *Ds*, is the angle between the vertical plane through the Line of Sight and the vertical plane through the Line of Fire, measured in a slant plane.

For clarity, the slant plane in which *Ds* is measured is shown at the elevation of the Present Line of Sight. It is explained later that this slant plane is actually at a different elevation.

The computed fuze time is called Fuze Setting Order, *F*. Fuze Setting Order, *F*, is the computed time between the firing of the gun and the burst of the projectile.

In order for the Prediction Section to compute *Vs* and *Ds*, the length of time required for the projectile to reach the Target must be computed. This quantity is called Time of Flight, *Tf*. Knowing the Time of Flight and the rates at which Range, Elevation and Bearing are changing, the changes in Range, Elevation and Bearing that take place during the Time of Flight can be computed. These changes are used to determine where the Target will be at the end of the Time of Flight. Target Position at the end of the Time of Flight is called Predicted Target Position.

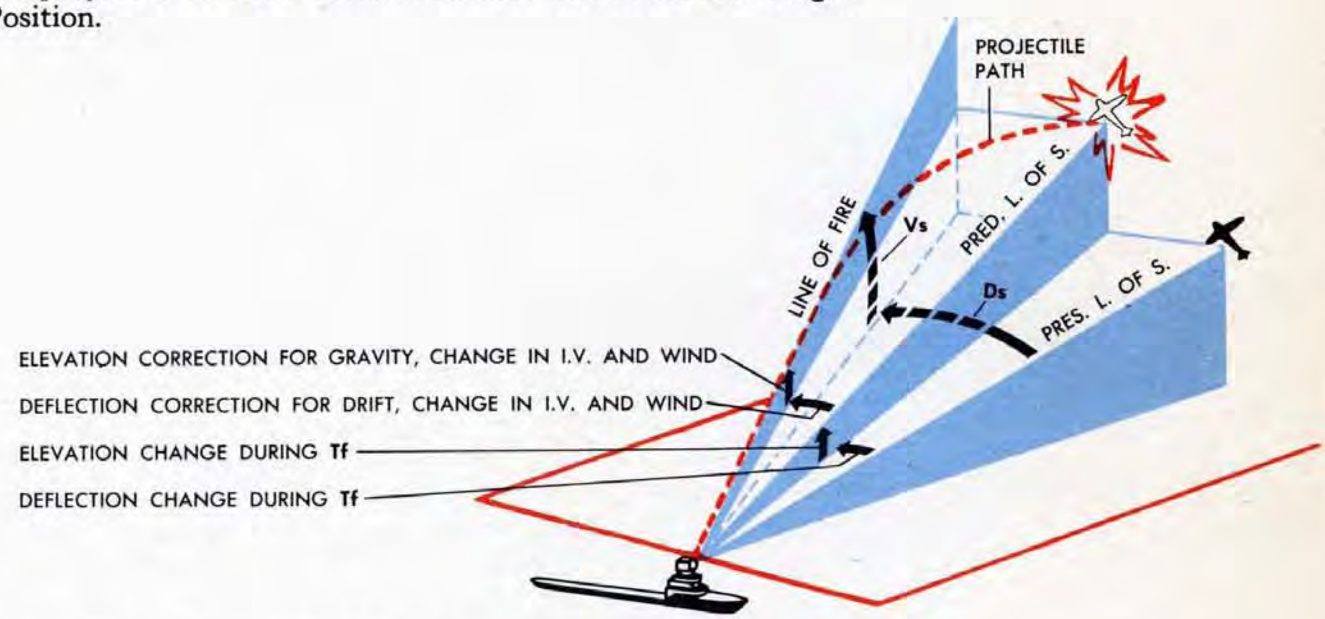


The Prediction Section performs three basic operations in computing lead angles *Vs* and *Ds* and Fuze Setting Order, *F*.

First it computes the Predicted Target Position and the Predicted Line of Sight to this predicted position. The Range to the Predicted Position is called Advance Range, *R2*. The Elevation of the Predicted Position is called Predicted Elevation, *E2*.

Second, it uses the Range and Elevation of the Predicted Target Position to compute the angles by which the Line of Fire must be offset from the Predicted Line of Sight to allow for the ballistic quantities: Gravity, Drift, Wind, and Changes in Initial Velocity of the projectiles.

Third, it uses the Range and Elevation of the Predicted Target Position to compute Fuze Setting Order, *F*, which will cause the projectile to burst when it reaches the Predicted Target Position.

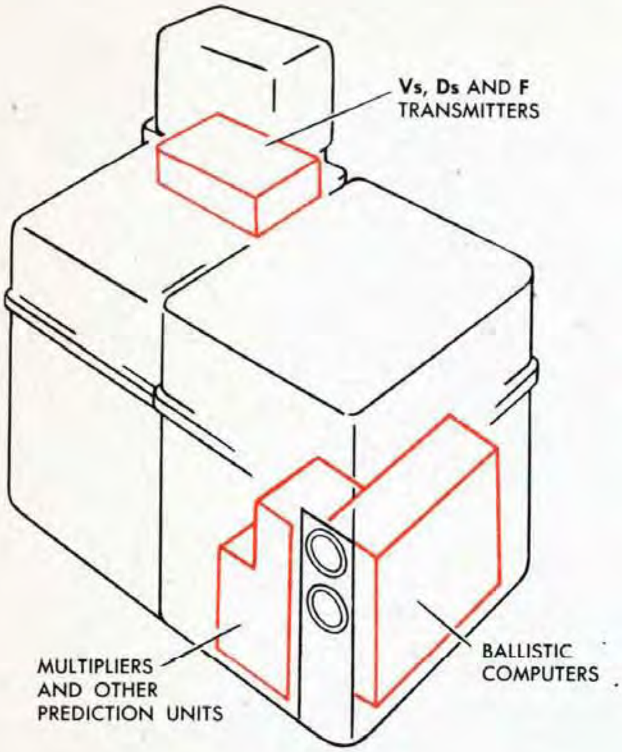


Sight Angle, *Vs*, and Sight Deflection, *Ds*, are the angles by which the Line of Fire must be offset from the Present Line of Sight to allow for all the Prediction factors.

With the guns aimed along the Line of Fire, the curved trajectory will carry the projectile *down* and *over* to the Predicted Target Position.

The Line of Fire established by *Vs* and *Ds* is established from a horizontal plane and is correct only when the deck is horizontal.

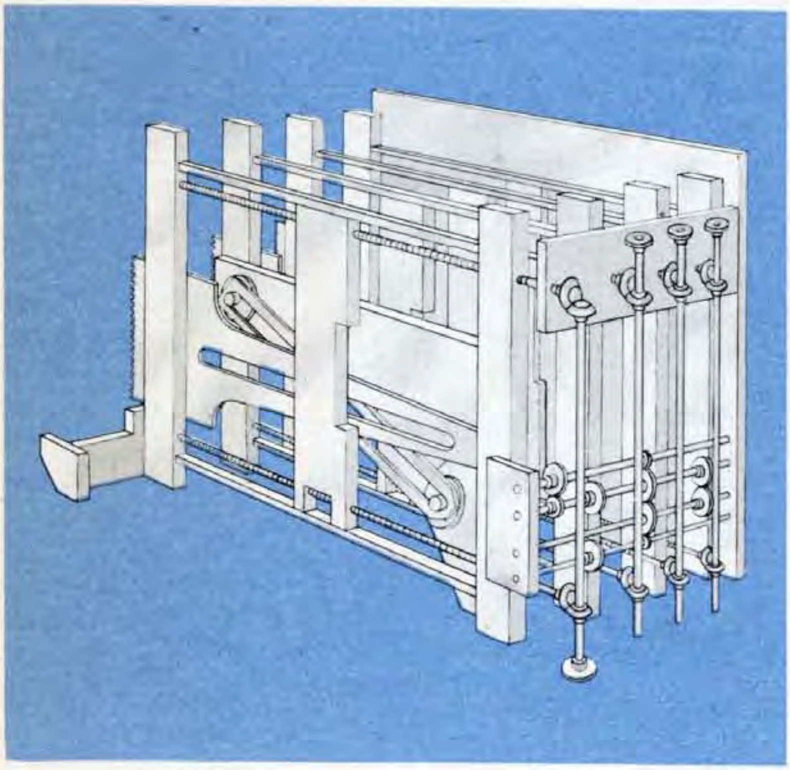
The MECHANISM in the PREDICTION SECTION



The mechanism in the Prediction Section includes: four Prediction Multipliers, four Ballistic Computers, the Range Rate Corrector, the Complementary Error Corrector, two Wind Component Solvers, five Follow-ups in addition to those in the Ballistic Computers, three Single-speed Spot Receivers, the Fuze, Sight Angle, and Sight Deflection Transmitters, and various differentials, handcranks, dials, and counters.

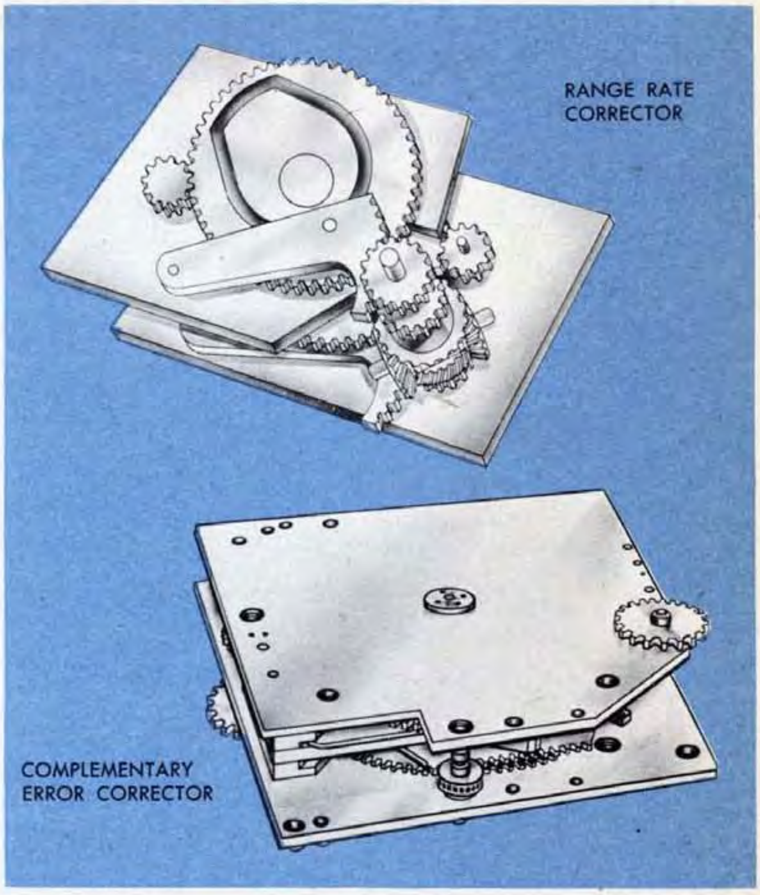
The Prediction Multipliers, Ballistic Computers, Range Rate Corrector, Complementary Error Corrector, and the Prediction Follow-ups are all located in the lower front section of the Computer Mark 1. The *Vs*, *Ds*, and *F* Transmitters are located in the upper rear section of the Computer.

The locations of the Wind Component Solvers and the Spot Receivers are described later in this chapter.

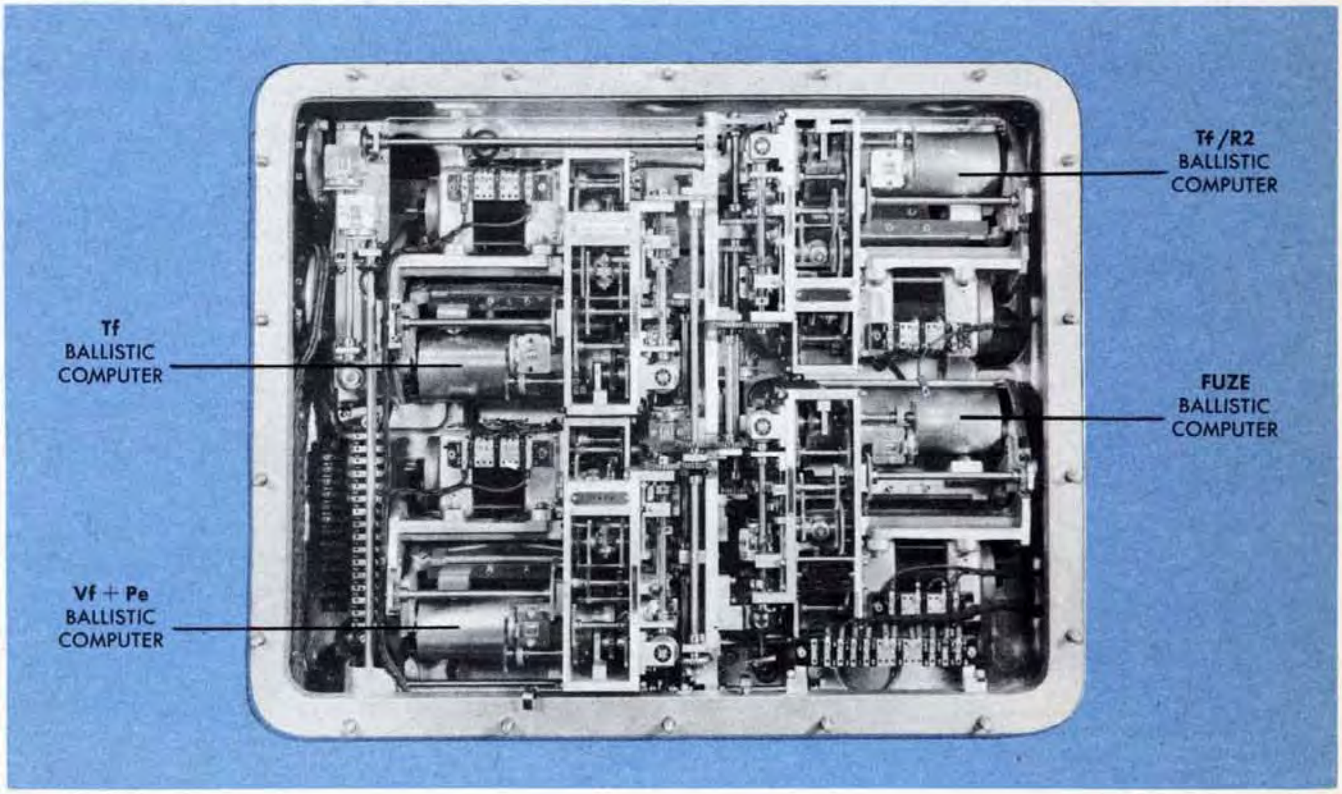


THE PREDICTION MULTIPLIERS are four screw-type multipliers assembled together in a bank. Three of these multipliers are used to compute the changes in Range, in Elevation, and in Deflection, during the Time of Flight. The fourth multiplier is used to compute the change in Range during the time between the setting of the fuze and the firing of the projectile.

THE RANGE RATE CORRECTOR and THE COMPLEMENTARY ERROR CORRECTOR are double-cam computing units which compute a Range Rate Correction and an Elevation Correction respectively.

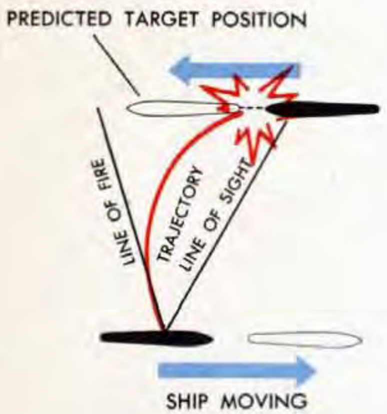


THE BALLISTIC COMPUTERS are four assemblies, each containing a barrel-type cam, a follow-up, and various shafts and gears. One ballistic computer computes each of the following quantities: Time of Flight, *Tf*, Time of Flight divided by Advance Range, *Tf/R2*, Superelevation plus Elevation Parallax, *Vf + Pe*, and Fuze Setting Order, *F*.



Why relative motion rates are used in prediction

While the projectile is in the air, both Target and Own Ship are moving. The motion of the Target during the Time of Flight affects the gun aim because it determines where the Target will be when the projectile arrives. The motion of Own Ship during the Time of Flight also has an effect on the gun aim, although the projectile leaves Own Ship at the beginning of the Time of Flight.



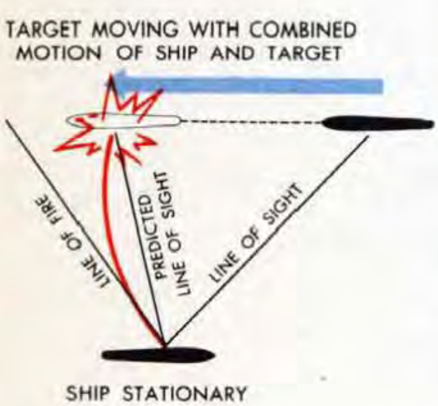
The motion of Own Ship affects the gun aim because it affects the trajectory of the projectile. *A projectile fired from a moving ship, besides moving in the direction in which the gun is pointed, also moves in the same direction and at the same speed as the ship is moving at the moment when the projectile leaves the gun.*

To demonstrate this fact, assume that Own Ship is stationary. A projectile is fired at a Predicted Target Position, directly abeam, and makes a hit.

Now assume that Own Ship is moving. A projectile is fired from exactly the same place, in exactly the same direction, at the same Predicted Target Position, but this time the projectile will burst behind the Predicted Target Position, because the projectile is moving in the direction and with the speed of Own Ship, in addition to the motion imparted by the firing of the gun.

If instead of Own Ship moving, Own Ship were stationary and the Target were moving with the combined velocity of the previous Ship and Target Motion, the effect on the Prediction calculations would be almost the same.

For example, here is a case in which Own Ship and Target are both moving. The Line of Fire is computed to allow for motion of the Target during the Time of Flight and the extra curvature of the trajectory due to Ship Motion.



Here Own Ship is stationary and the Target is moving with the combined velocity of Ship and Target in the previous case. The Line of Fire is almost the same as in the previous case, since the extra motion of the Target is offset by the straighter trajectory of the projectile.

Since the effect of Own Ship Motion is approximately the same as that of additional Target Motion, the Relative Motion Rates, *dR*, *RdE*, and *RdBs*, are used instead of Target Motion Rates in computing the Predicted Position of the Target. Thus the Prediction Section allows for the effect of Own Ship Motion on the trajectory by treating Own Ship Motion as if it were additional Target Motion.

Predicted target position

To obtain the change in Target Position relative to Own Ship during the Time of Flight, the three Relative Motion Rates must be multiplied by Time of Flight, *Tf*. The three products represent the approximate *linear* movement of the Target while the projectile is in flight:

1. The linear Range Rate multiplied by Time of Flight is the approximate change in Range during the Time of Flight.

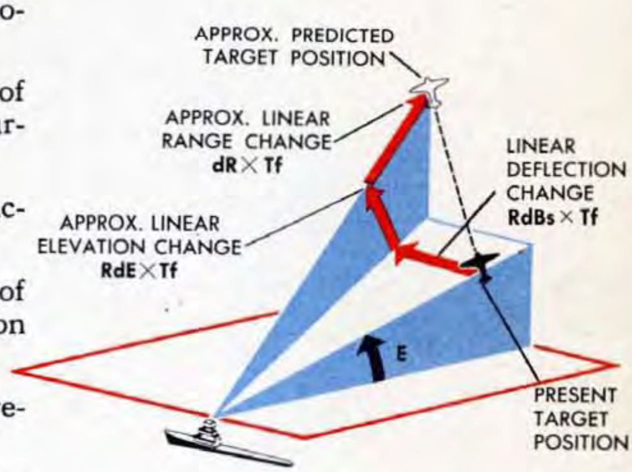
   $dR \times Tf$ = Approximate Linear Range Prediction

2. The linear Elevation Rate multiplied by Time of Flight is the approximate change in Elevation during the Time of Flight.

   $RdE \times Tf$ = Approximate Linear Elevation Prediction

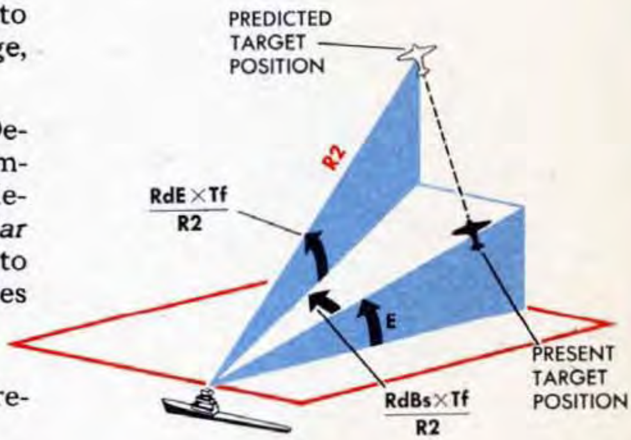
3. The linear Deflection Rate multiplied by Time of Flight is the approximate change in Deflection during the Time of Flight.

   $RdBs \times Tf$ = Approximate Linear Deflection Prediction



$dR \times Tf$, if added to Generated Present Range, *cR*, will produce an approximate value of the Range to the Predicted Target Position, called Advance Range, *R2*.

Before the Target movement in Elevation and Deflection during the Time of Flight can be used in computing the lead angles, the *linear* predictions in Elevation and Deflection must be converted into *angular* predictions. The linear quantities are converted to angular quantities by dividing the linear quantities by Advance Range, *R2*.

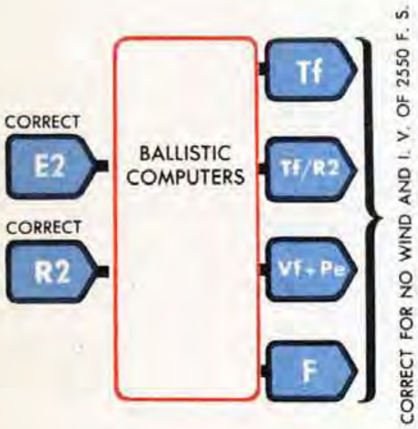


$\frac{RdE \times Tf}{R2}$ is an approximate *Angular* Elevation Prediction. The quantity $\frac{RdE \times Tf}{R2}$ is added to Target Elevation, *E*, to produce an approximate value of the Elevation of the Predicted Target Position, called Predicted Target Elevation, *E2*.

The Angular Deflection Prediction is computed by the same method. $\frac{RdBs \times Tf}{R2}$ is an approximate Angular Deflection Prediction. The quantity $\frac{RdBs \times Tf}{R2}$ is used in computing Sight Deflection, *Ds*.

PREDICTED TARGET POSITION

Approximate values of Predicted Target Position in Range, Elevation, and Deflection are computed by multiplying the three Relative Motion Rates by *Tf* or *Tf/R2*. Since the change of position in two of the three directions is affected by motion in the other directions, corrections must be made to the approximate values of Predicted Target Position to make them accurate. The Range Prediction must be corrected for the effect of the Elevation and Deflection Predictions, and the Elevation Prediction must be corrected for the effect of the Deflection Prediction. When these corrections have been made, accurate values of *R2* and *E2* are obtained.

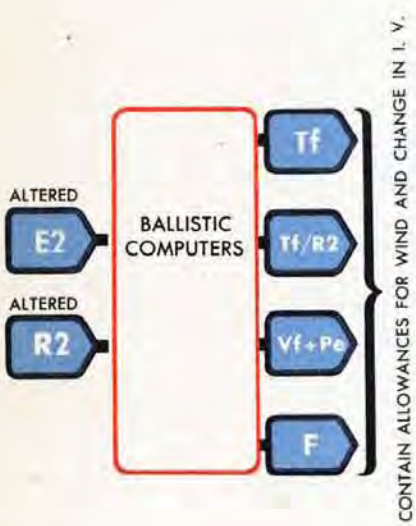


The accurate values of *R2* and *E2* are used as inputs to the ballistic computers which compute the ballistic quantities: Time of Flight, *Tf*, Time of Flight divided by Advance Range, *Tf/R2*, Superelevation plus Elevation Parallax, *Vf + Pe*, and Fuze Setting Order, *F*. The barrel cams in the ballistic computers are cut in such a way that the output values of *Tf*, *Tf/R2*, *Vf + Pe*, and *F* correspond to the particular combination of values of *R2* and *E2* going into the ballistic computers, that is, *the ballistic values are related to the Predicted Target Position.*

The ballistic values on the cams do not make allowances for Wind or for changes in the Initial Velocity of the projectile, although both these factors change the trajectory of the projectile.

To correct the outputs from the ballistic computers for Wind and Initial Velocity, alterations are made to the cam inputs, *R2* and *E2*.

The Computer Mark 1 computes an imaginary Predicted Target Position such that the trajectory computed using the *R2* and *E2* of this *imaginary* Predicted Target Position will place the shells at the *actual* Predicted Target Position.



Using the *R2* and *E2* of this imaginary Predicted Target Position as inputs to the ballistic computers, ballistic predictions are computed which are combined with the values of the Imaginary Target Position to establish a Line of Fire *which allows for motion of Ship and Target during the Time of Flight and also for Wind and changes in Initial Velocity.*

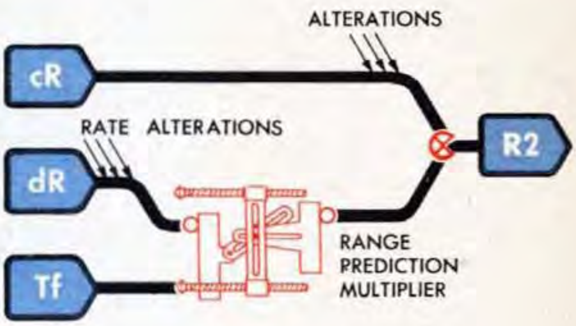
The Prediction Multipliers

Both in correcting the approximate values of Predicted Target Position to make them accurate and in altering the accurate Predicted Target Position values to allow for Wind and changes in Initial Velocity, the values needed depend on the length of the Time of Flight.

Since both the rates and the correction and alteration quantities must be multiplied by the same *Tf* or *Tf/R2*, they are combined and fed into the same set of multipliers. This avoids using separate multipliers for the modifying quantities alone. In this way each rate and the quantities used in correcting and altering it are multiplied by *Tf* or *Tf/R2* in one multiplier.

Range prediction

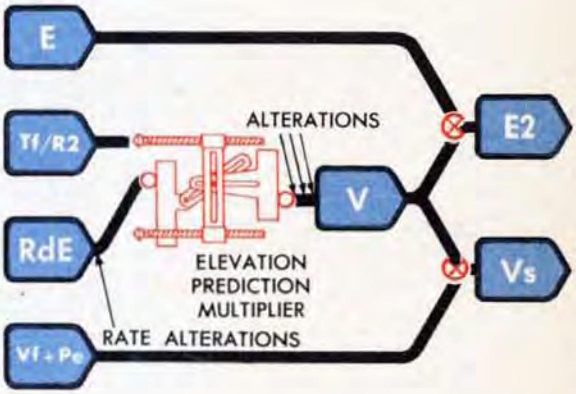
Direct Range Rate, *dR*, altered by three additional quantities, is one input to the Range Prediction Multiplier. Time of Flight, *Tf*, is the other input. Generated Present Range, *cR*, is altered by three linear quantities. The altered *cR* is added to the output of the Range Prediction Multiplier in a differential. The output of the differential is Advance Range, *R2*, containing allowances for Wind and changes in Initial Velocity.



Elevation prediction

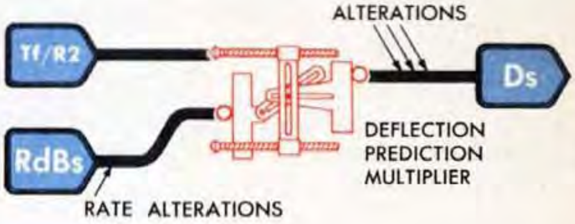
Elevation Rate, *RdE*, altered by one additional quantity is one input to the Elevation Prediction Multiplier. *Tf/R2* is the other input. The multiplier output is altered by three linear quantities to obtain Elevation Prediction, *V*.

Elevation Prediction, *V*, plus Present Target Elevation, *E*, is Predicted Target Elevation, *E2*. *V* plus one quantity to allow for Superelevation and Vertical Parallax is Sight Angle, *Vs*. Both *E2* and *Vs* contain allowances for Wind and changes in Initial Velocity.



Deflection prediction

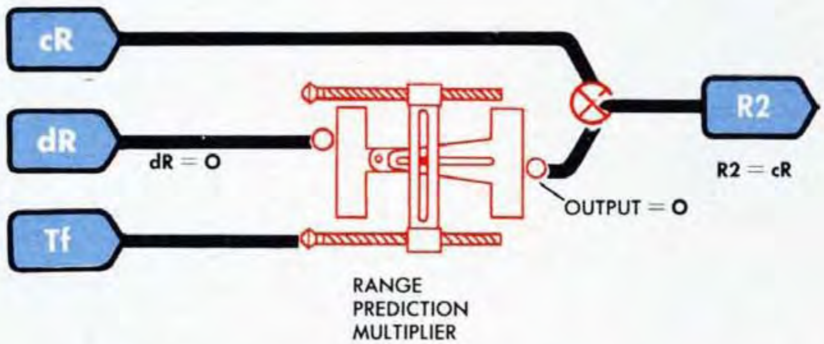
Deflection Rate, *RdBs*, altered by one additional quantity, is one input to the Deflection Prediction Multiplier. *Tf/R2* is the other input. The multiplier output is altered by three additional quantities to obtain an accurate value of Sight Deflection Angle, *Ds*, which contains allowances for Wind and changes in Initial Velocity.



Regeneration

In describing the computation of the predicted values of Range, Elevation, and Bearing, it has been assumed so far that the value of Time of Flight, *Tf*, is known. Actually the value of *Tf*, like that of several other quantities in the Prediction Section, depends on the values of *R2* and *E2*. All of these quantities, including *Tf*, are computed at the same time as *R2* and *E2*, by a method called *Regeneration*.

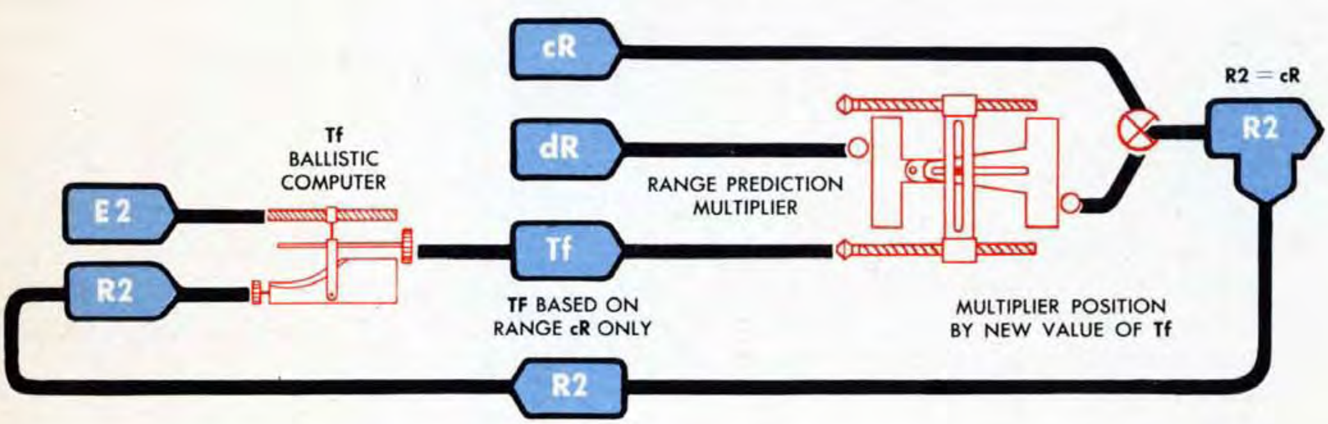
Regeneration is the use of an output from a network as an input to the same network. A study of the regeneration of *R2* in a simplified Range Prediction network will show how this is done.



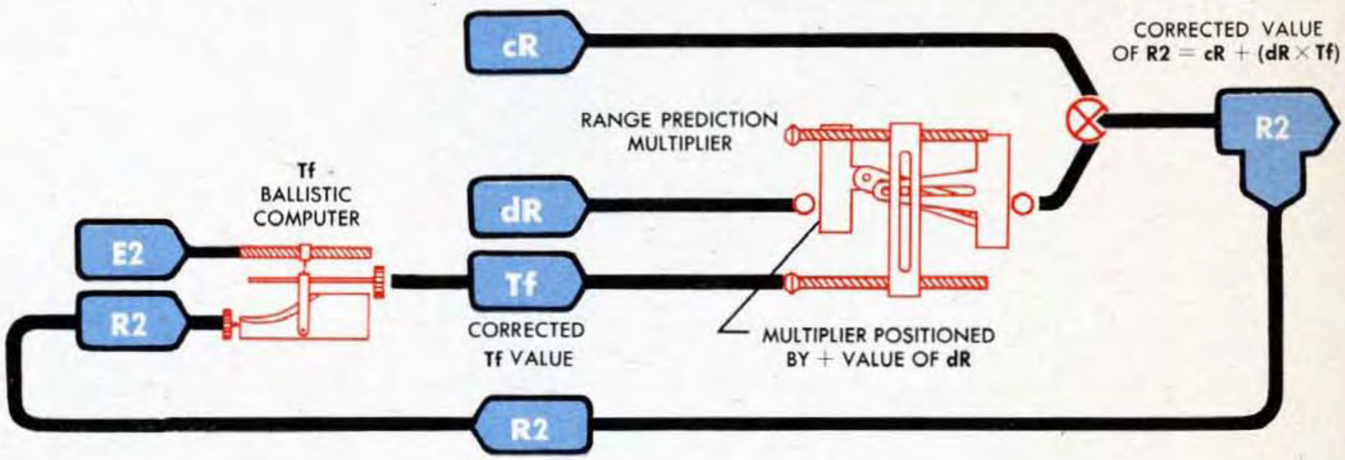
If the Direct Range Rate, *dR*, is zero, the output from the multiplier is also zero, and the value of the *R2* output from the network will be equal to *cR*.

This *R2* value is now fed back to become an input to the *Tf* Ballistic Computer. This *R2*,together with a value of *E2*, produces a value of *Tf* corresponding to this Range.

The new value of *Tf* positions the lead screw input of the Range Prediction Multiplier.



If Direct Range Rate, *dR*, now changes from zero to a positive value, this value of *dR* will be multiplied by the *Tf* value in the multiplier. The multiplier output will change the *R2* value, causing a small change in *Tf*. This change in *Tf* will cause a small additional change in *R2*. Both *R2* and *Tf* continue to change in value until the *Tf* value change is too small to affect the *R2* value. The *Tf* value then becomes the true value for the *R2* on the output line.

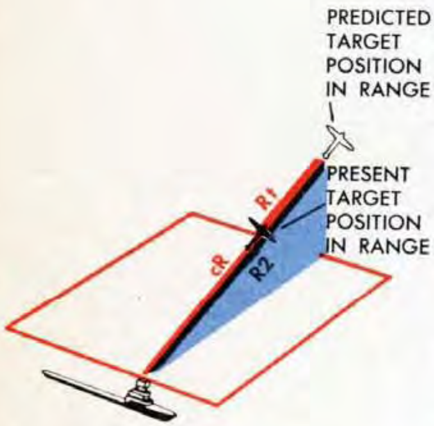


The whole regeneration process takes place almost instantly.

The following description covers the calculation of *R2* and *E2* for 2550 f.s. Initial Velocity and zero Wind. The way in which the Computer Mark 1 allows for changes in *I.V.* and effects of Wind by altering *R2* and *E2* will be described at the end of this chapter.

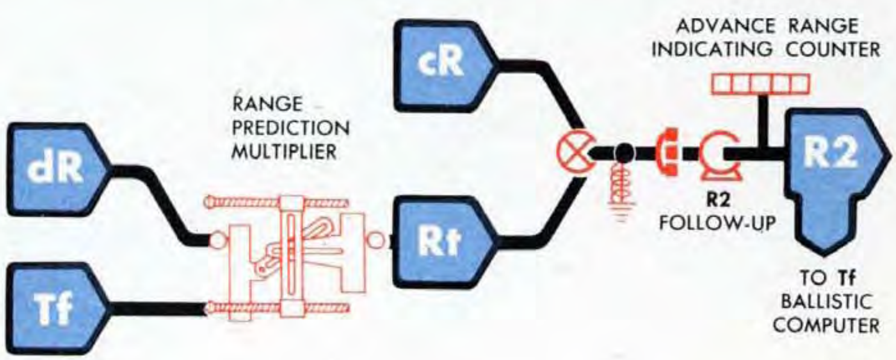
COMPUTING ADVANCE RANGE, R2

Three computing mechanisms are used in the *R2* network. They are: the Range Prediction Multiplier, the *Tf* Ballistic Computer, and the Range Rate Corrector.

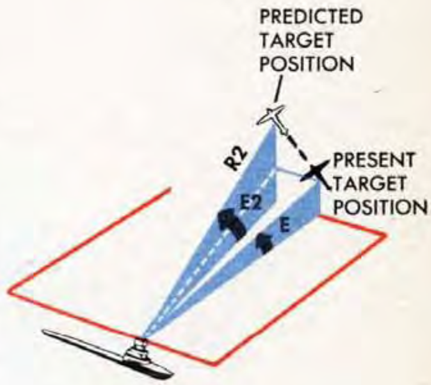


The range prediction multiplier

Direct Range Rate, *dR*, plus an additional rate to allow for the effect of the Elevation and Deflection Predictions on Range, is one input to the Range Prediction Multiplier. Time of Flight, *Tf*, from the *Tf* Ballistic Computer is the other input. The multiplier output is *Rt*. *Rt* is the Range change to compensate for the relative movement of Target and Own Ship during Time of Flight. *Rt* is added to Generated Present Range, *cR*, to obtain Advance Range, *R2*. This value of *R2* is the accurate Advance Range for 2550 *I.V.* and zero Wind. *R2* is amplified by a velocity-lag follow-up. A branch of the *R2* line feeds back to become an input to the *Tf* Ballistic Computer.

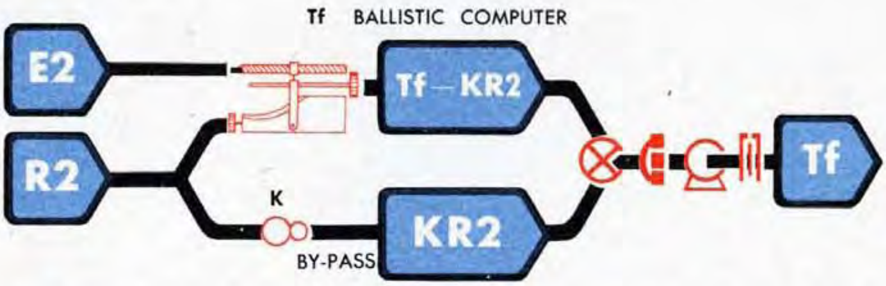


The Tf ballistic computer



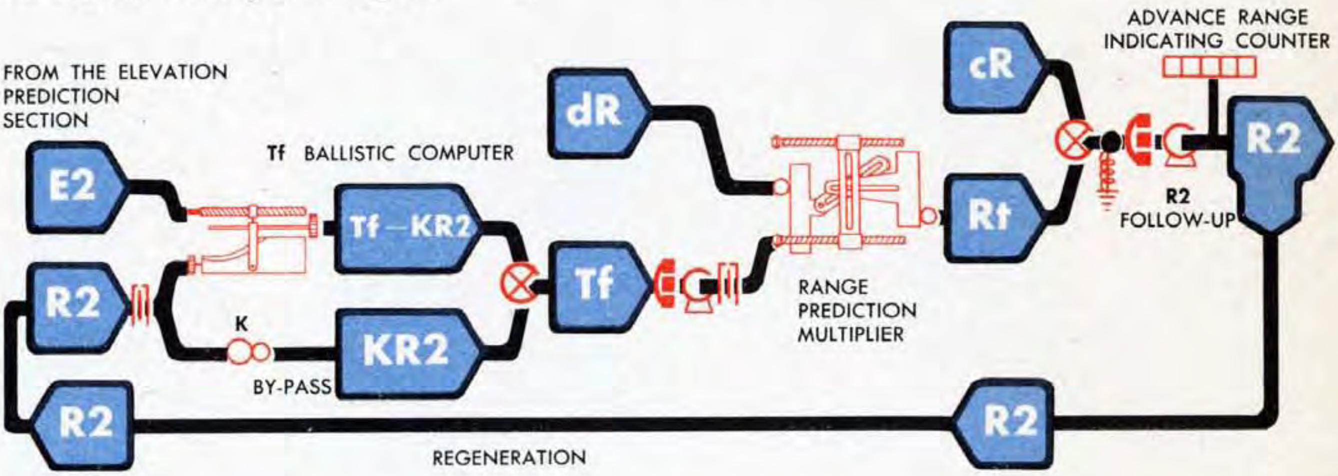
The two inputs to the *Tf* Ballistic Computer are Advance Range, *R2*, and Predicted Target Elevation, *E2*.

R2 turns the ballistic cam. *E2* moves the cam follower along the cam. The cam output is not the true value of *Tf* but is the difference between the true value and a straight-line approximation of *Tf*. The straight-line approximation is called *KR2*. The output of the cam is therefore *Tf* – *KR2*.



A branch of the *R2* line by-passes the *Tf* cam in the *Tf* Ballistic Computer. A gear ratio is used on this branch line to multiply *R2* by a constant to obtain the quantity *KR2*, which is the straight-line approximation of Time of Flight. *KR2* is added to the cam output, *Tf* – *KR2*, in a differential. The differential output is *Tf*.

The *Tf* Ballistic Computer contains a velocity-lag follow-up to increase the torque on the *Tf* line. The follow-up output is *Tf*, the Ballistic Computer output.

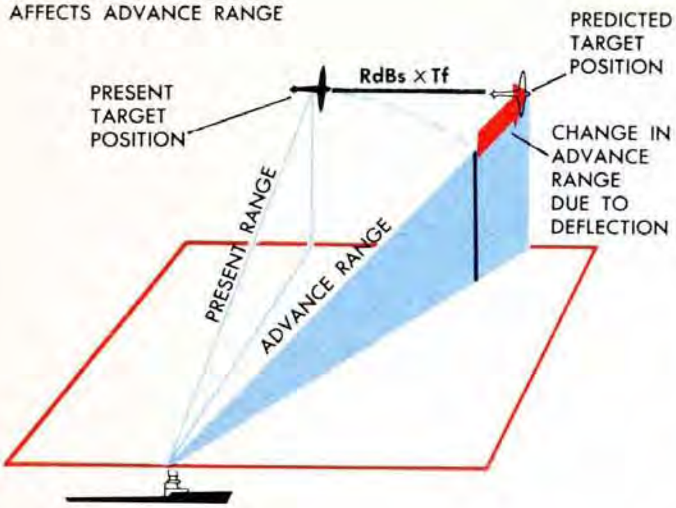


The range rate corrector

The quantity added to Range Rate, *dR*, to allow for the effect of Elevation and Deflection during the Time of Flight is computed in the Range Rate Corrector. This unit and the quantity it computes are described on the following page.

How Target Deflection and Elevation affect Advance Range

HOW TARGET DEFLECTION AFFECTS ADVANCE RANGE

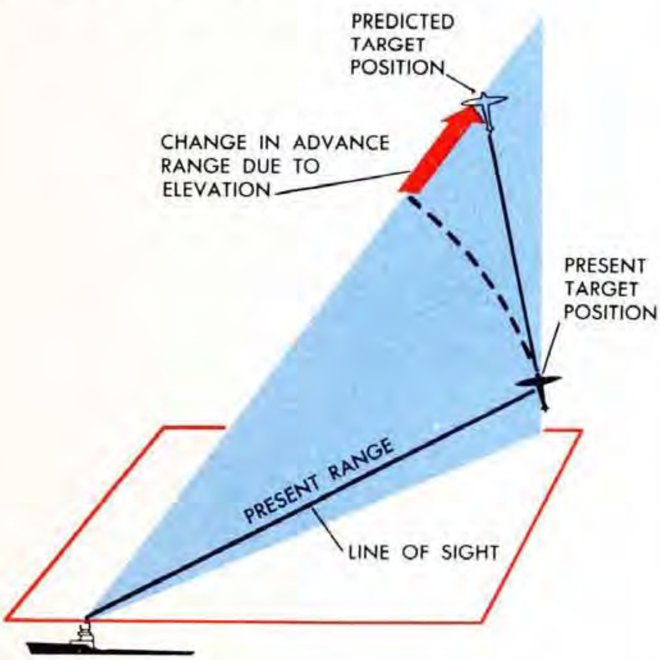


During the time of flight of a projectile, the linear Deflection and Elevation of the Target cause linear changes in Advance Range. This can be shown by studying the movement of a Target during the Time of Flight, beginning at an instant when Direct Range Rate, *dR*, is zero. Remember that the Computer Mark 1 assumes the Target is traveling a straight course.

How target deflection affects range

Direct Range Rate, *dR*, is zero when Target Angle, *A*, is exactly 90 degrees. If *A* is 90° and the Target travels horizontally at right angles to the Line of Sight, Range to a Target traveling a straight course increases during the Time of Flight by an amount represented by the red arrow.

HOW TARGET ELEVATION AFFECTS ADVANCE RANGE



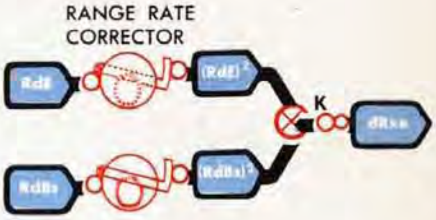
How target elevation affects range

Suppose that at the beginning of the Time of Flight the Target is climbing at right angles to the Line of Sight in the vertical plane through the Line of Sight. Range Rate, *dR*, is zero. As the Target flies to its Predicted Position during the Time of Flight, Range increases by an amount represented by the red arrow.

The total linear correction to Range caused by Target Elevation and Deflection during the Time of Flight is the sum of changes represented by the two red arrows.

Computing the Correction

To find the linear correction to Range for Deflection and Elevation during the Time of Flight, an alteration to the Range *Rate* is computed so that, when multiplied by Tf, it will produce the desired *linear* correction to Range. This alteration is called Range Rate Correction, $dRxe$. The equation for solving $dRxe$ is: $dRxe = [(RdE)^2 + (RdBs)^2] \times K$. This equation is solved in the Range Rate Corrector.

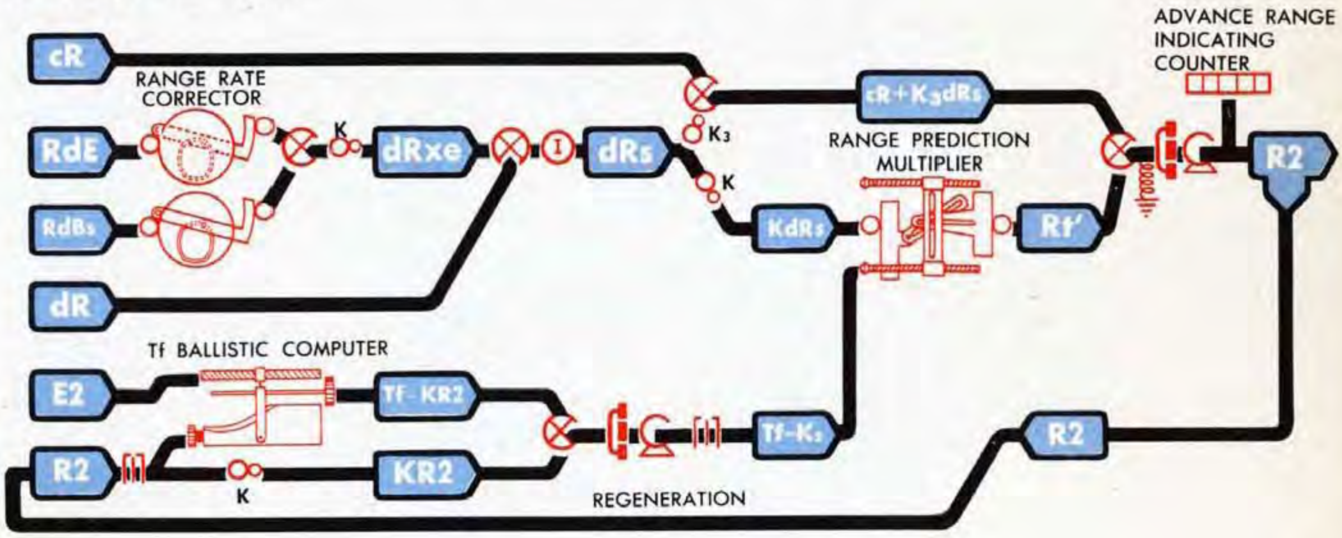


The Range Rate Corrector contains a differential and two "square" computing cams, each with a sector follower. Elevation Rate, RdE, is the input to one cam. Deflection Rate, $RdBs$, is the input to the other cam. The cam outputs are $(RdE)^2$ and $(RdBs)^2$. These two quantities are added in the differential. K is introduced by a gear ratio. The output of the gear ratio is $dRxe$, the output of the Range Rate Corrector.

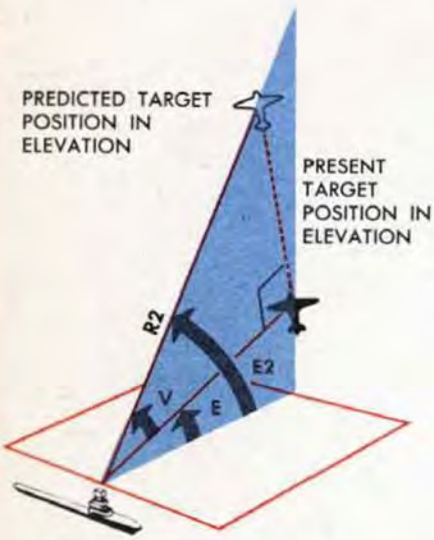
The alteration $dRxe$ must be multiplied by Tf to produce the Total Linear Correction to Range. In the Computer Mark 1, it does not exist as a separate quantity but is part of the output from the Range Prediction Multiplier. The alteration $dRxe$ combines with the Direct Range Rate, dR. dR plus $dRxe$ is called Prediction Range Rate, dRs. dRs positions the rack of the Range Prediction Multiplier and is multiplied by Time of Flight, Tf. The multiplier output is Rt', which consists of the Linear Range Change during Time of Flight, plus the Linear Correction to Range caused by the Deflection and Elevation of the Target during the Time of Flight.

The dRs input to the Range Prediction Multiplier is multiplied by a constant K. The Time of Flight input to the multiplier is Tf minus a constant K_2, or $Tf - K_2$. These constants are needed in computing the Range correction for Wind, and will be explained in detail later.

The constant, K_2, introduced in the multiplier input, $Tf - K_2$, produces an error in the multiplier output. To remove this error, a branch of the dRs line is multiplied by another constant, K_3, through ratio gearing to obtain a correction quantity, K_3dRs. K_3dRs is added to Generated Range, cR. When $cR + K_3dRs$ is added to the multiplier output, K_3dRs corrects the error in the multiplier output.



COMPUTING PREDICTED TARGET ELEVATION, E2



Predicted Target Elevation, $E2$, is the sum of Target Elevation, E, and Elevation Prediction, V.

$$E2 = E + V$$

Without corrections for Wind or changes in Initial Velocity, Elevation Prediction, V, is Vt, the Angular Change in Elevation during the Time of Flight, minus Vx, an Angular Correction for Complementary Error.

$$V = Vt - Vx$$

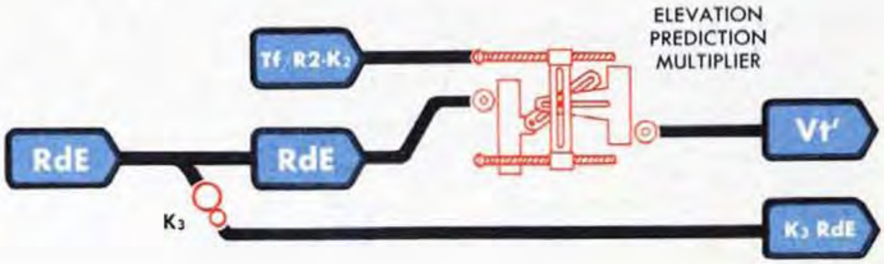
Vt is computed in the Elevation Prediction Multiplier network. Vx is computed in the Complementary Error Corrector.

The Elevation Prediction Multiplier has two inputs: the Linear Elevation Rate, RdE, and Time of Flight divided by Advance Range, $Tf/R2$. RdE positions the input rack; $Tf/R2$ positions the lead screw. RdE multiplied by Tf would produce the *linear* change in Elevation during Time of Flight. Since an *angular* change in Elevation during Time of Flight is needed to aim the guns, RdE is multiplied by Tf and divided by $R2$. The multiplier output is Vt.

$$\frac{RdE \times Tf}{R2} = Vt$$

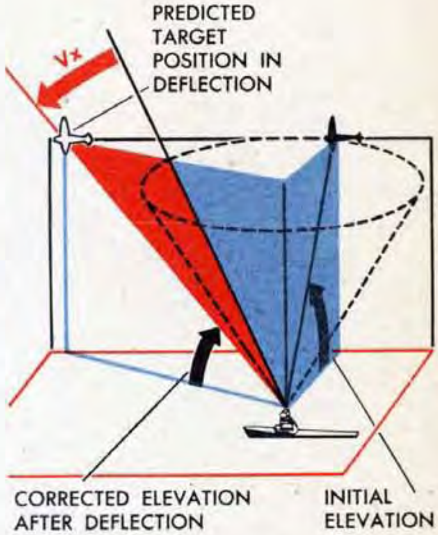
Vt is the Elevation Prediction which compensates for the relative motion of Target and Own Ship during the Time of Flight.

Actually the input to the lead screw of the Elevation Prediction Multiplier is $Tf/R2 - K_2$. The constant, K_2, is needed in connection with a Wind rate allowance which will be explained in detail later. Because of this constant in the input, the multiplier output is not Vt, but Vt', and contains an error. To correct this error, a branch of the RdE line is multiplied by another constant, K_3, in a gear ratio. K_3RdE by-passes the multiplier and is added to the multiplier output, Vt', after the Complementary Error Correction, Vx, has been subtracted from Vt'.



Complementary Error is the change in Elevation caused by the Deflection Prediction.

The effect on Elevation of a train correction for Target Deflection can be seen by studying a simple problem. Assume that the target is flying on a straight course at right angles to the Line of Sight, at a constant height, and at a constant speed. The Range and the height of the Target at the Present Target Position establish the Initial Elevation.



The diagram shows that if a train correction only were made to compensate for Target Deflection, the Predicted Line of Sight would not run to the Target but would pass above it. The Deflection of the Target has made necessary a smaller angle of Elevation. This change in Elevation is the Complementary Error.

To allow for the Complementary Error, Predicted Elevation must be reduced by a computed quantity called Complementary Error Correction, Vx. Vx is subtracted from Vt to obtain an accurate value of Elevation Prediction, V.

The value of Vx is computed in the Complementary Error Corrector. It is the product of $(Ds)^2$ and a function of $E2$.

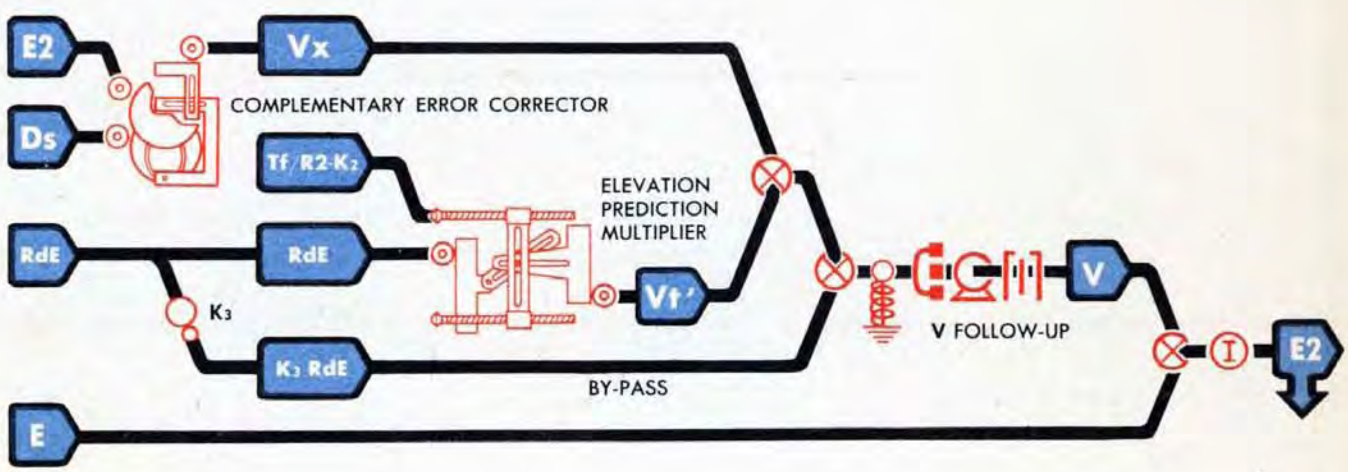
$$Vx = (Ds)^2 \times f(E2)$$

The Complementary Error Corrector is a two-cam computing multiplier. The two inputs are Sight Deflection, Ds, and Predicted Elevation, $E2$. Ds is squared by one cam and a function of $E2$ is computed by the other cam. $(Ds)^2$ is then multiplied by $f(E2)$. The multiplier output is the Complementary Error Correction, Vx. Vx is subtracted from the Elevation Prediction Multiplier output, Vt', at a differential. The differential output is added to the multiplier by-pass, K_3RdE, to obtain V. V is the corrected angular Elevation Prediction to compensate for Target Motion during Time of Flight.

$$V = Vt' - Vx + K_3RdE = Vt - Vx$$

V is amplified by a velocity-lag follow-up and is added to Target Elevation, E, to obtain Predicted Target Elevation, $E2$.

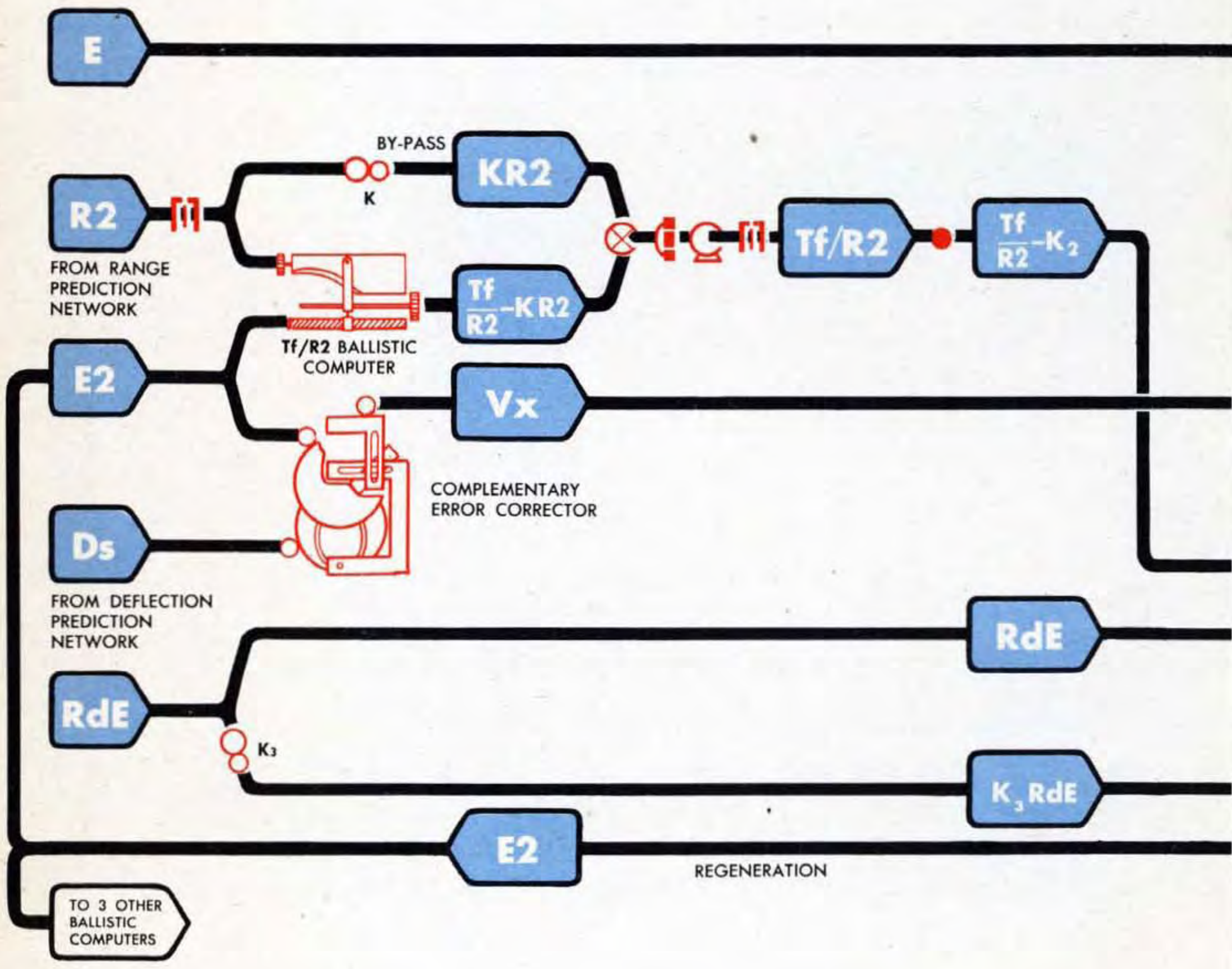
$$E2 = V + E$$



The Elevation Prediction Network

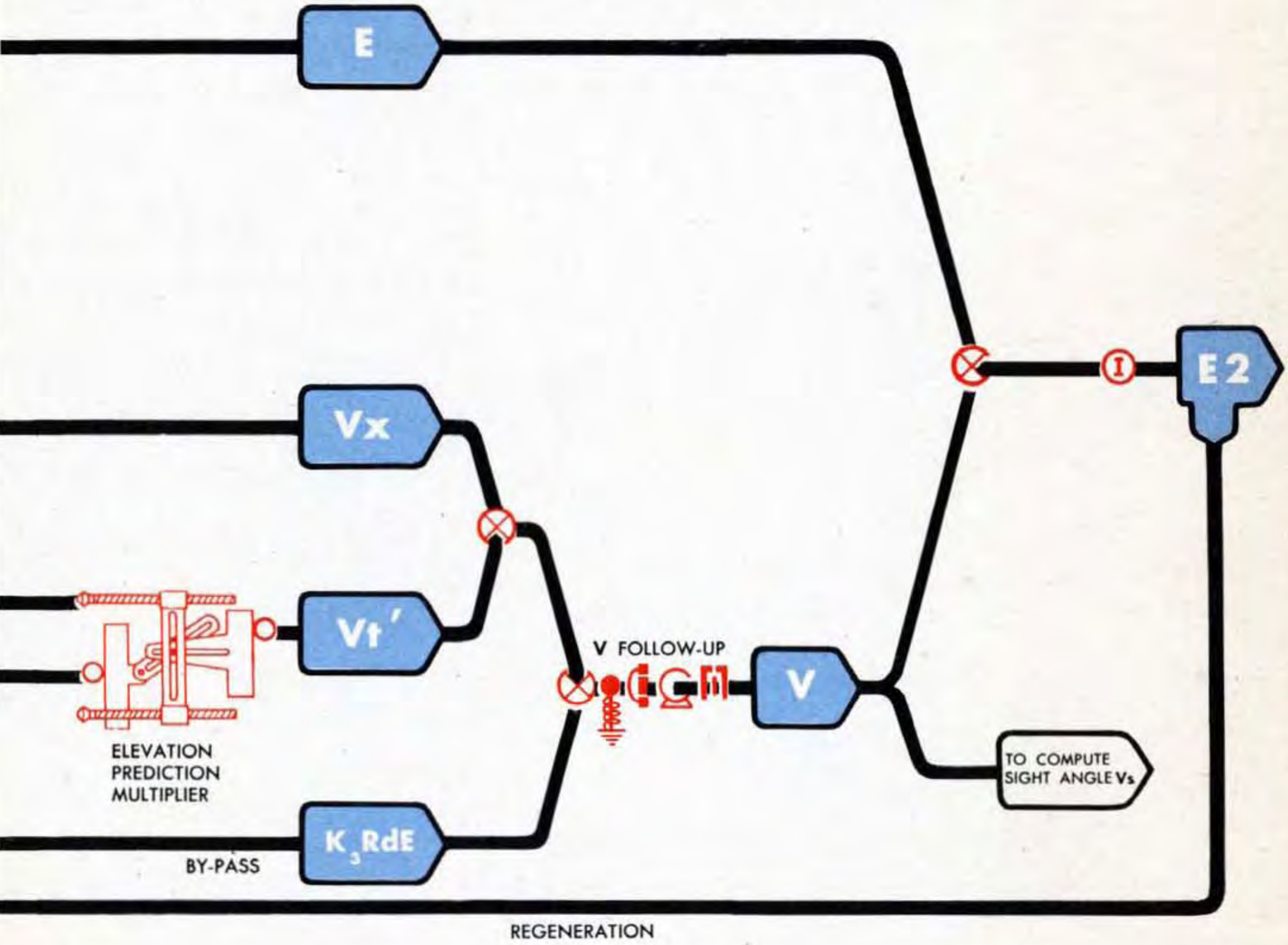
Predicted Elevation, $E2$, regenerates in the same way as Advance Range, $R2$. $E2$ becomes an input to the $Tf/R2$ Ballistic Computer. The other input to this Computer is $R2$.

$R2$ rotates the cam of the $Tf/R2$ Ballistic Computer while $E2$ moves the cam follower along the cam. The cam output is $Tf/R2 - KR2$, which is the difference between $Tf/R2$ and a straight-line approximation of $Tf/R2$.

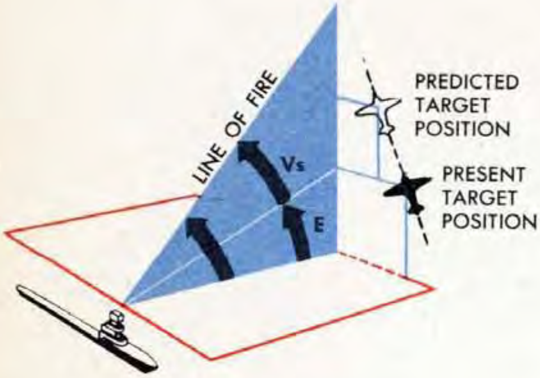


A branch of the $R2$ shaft line by-passes the $Tf/R2$ cam. Ratio gearing on this shaft line multiplies $R2$ by K to produce $KR2$, which is a straight-line approximation of $Tf/R2$. $KR2$ is added to the cam output $Tf/R2 - KR2$ to obtain $Tf/R2$. $Tf/R2$ is amplified by a velocity-lag follow-up and is the output of the ballistic computer. $Tf/R2$ is then used in the Elevation Prediction Multiplier.

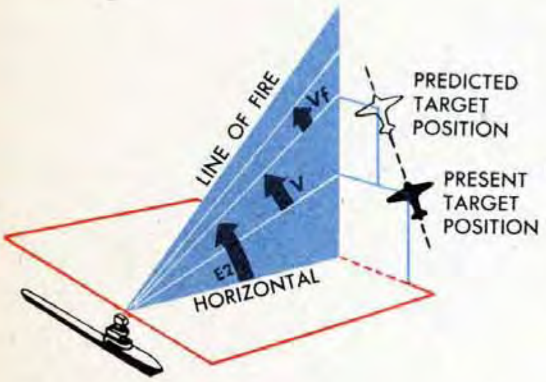
$E2$ also regenerates to become an input to the Time of Flight, $Vf + Pe$, and Mechanical Fuze Ballistic Computers. $E2$ is also a regenerative input to the Complementary Error Corrector and to the Elevation Wind Component Solver which is described later in this chapter.



COMPUTING SIGHT ANGLE, Vs



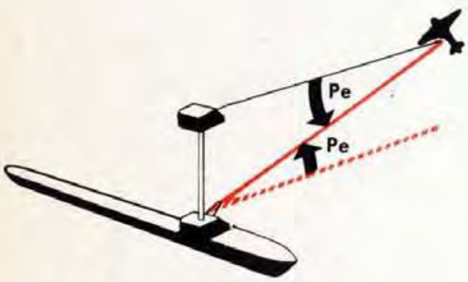
Sight Angle, *Vs,* is the angular difference between the elevation of the Line of Fire above the horizontal and the elevation of the Line of Sight above the horizontal, both of these elevation angles being measured in vertical planes.



Without allowance for Wind or changes in Initial Velocity, *Vs* is made up of three Elevation quantities: *V, Vf,* and *Pe.*

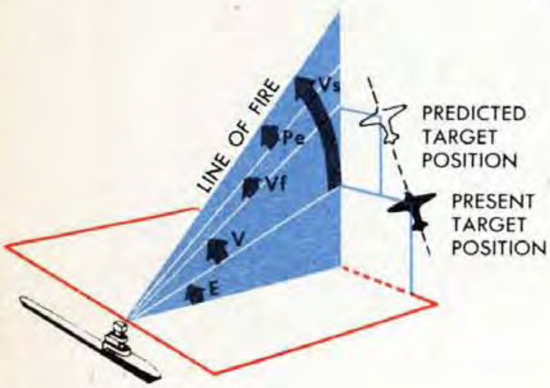
1 Elevation Prediction, *V,* is the angular Elevation change during Time of Flight. *V* is the vertical angle between the slant plane of the Present Line of Sight and the slant plane of the Predicted Line of Sight.

2 Superelevation, *Vf,* is the angle the gun must be elevated above Predicted Target Elevation, *E2,* to compensate for curvature of the trajectory in the vertical plane.



3 Elevation Parallax Correction, *Pe,* is the angle needed to compensate Gun Elevation for the vertical difference between the height of the Director and the height of the gun.

When no wind is blowing and when the Initial Shell Velocity is 2550 f.s., $Vs = V + Vf + Pe$.

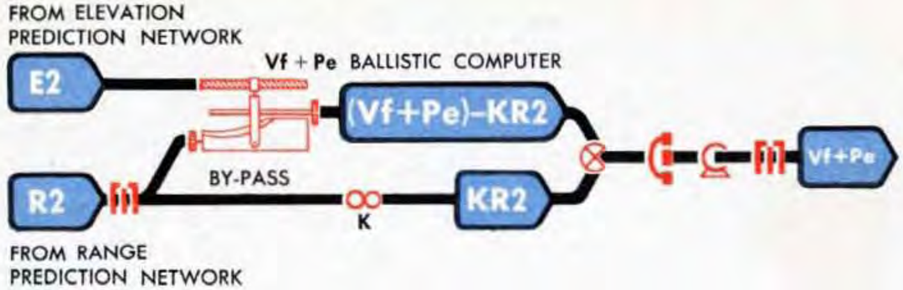


The computation of *V* has been described in the Elevation Prediction network. $V = Vt - Vx$. *Vf* and *Pe* are both computed in one ballistic computer.

A detailed description of the Elevation Parallax Correction, *Pe,* is given in the chapter on Parallax, page 350.

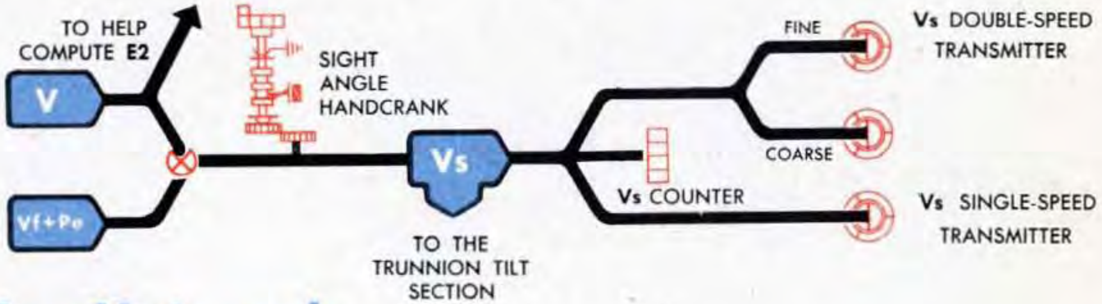
The $Vf+Pe$ Ballistic Computer

Superelevation, Vf, and Elevation Parallax Correction, Pe, are both computed in one ballistic computer. This is possible because both Superelevation and Elevation Parallax are functions of Advance Range, $R2$, and Predicted Target Elevation, $E2$.



$R2$ rotates the ballistic cam in the $Vf + Pe$ Ballistic Computer. $E2$ moves the cam follower along the cam. The cam computes the difference between the true value of $Vf + Pe$ and a straight-line approximation of $Vf + Pe$. The straight-line approximation is called $KR2$. The cam output is $(Vf + Pe) - KR2$. A branch of the $R2$ line by-passes the cam. Ratio gearing on this line multiplies $R2$ by a constant, producing the straight-line approximation, $KR2$. $KR2$ is added to the cam output $(Vf + Pe) - KR2$, to obtain $Vf + Pe$. A velocity-lag follow-up amplifies the torque on the line. The follow-up output is the ballistic computer output, $Vf + Pe$.

$Vf + Pe$ is an angular Elevation Correction and is added to V in a differential to obtain Sight Angle, Vs.



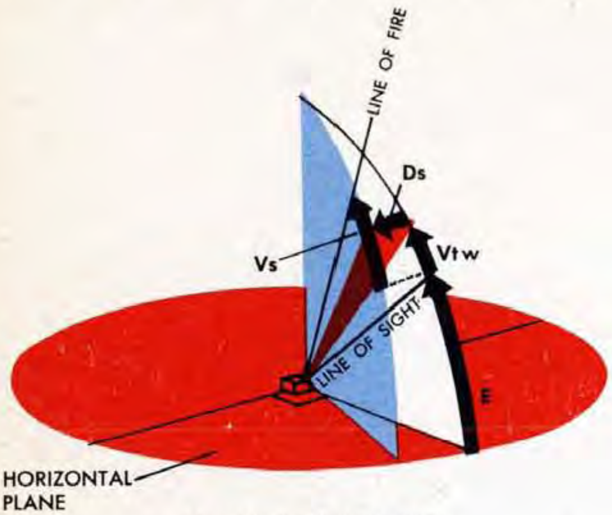
How Vs is used

Sight Angle, Vs, goes to the Trunnion Tilt Section of the Computer Mark 1 where it is used in computing the Gun Orders.

Vs also positions the two Sight Angle Transmitters. One of these is a double-speed transmitter. The other is a single-speed transmitter. Both transmitters send Vs to the gun mounts to offset the gun sights.

If some of the Computer's transmission circuits are not energized but the circuits for the Sight Angle Transmitters are energized, these transmitters may be set by hand according to any information available. This is done by turning the Sight Angle Handcrank in the IN position and watching the Sight Angle Counter. The handcrank and counter are on the rear top of the Computer.

COMPUTING SIGHT DEFLECTION, Ds



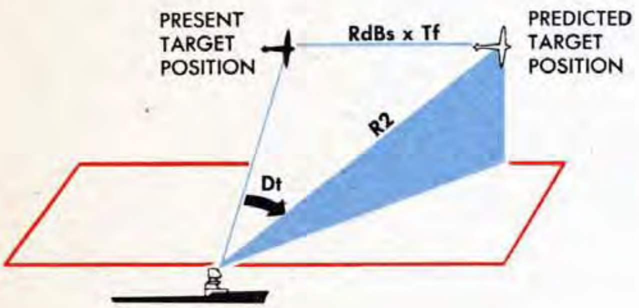
Ds WHEN WIND IS ZERO AND I.V. IS 2550 F. S.

Sight Deflection, *Ds*, is the angle between the vertical plane through the Line of Sight and the vertical plane through the gun axis. *Ds* is measured in a slant plane at right angles to the vertical plane through the Line of Sight, at angle *Vtw* above the Line of Sight.

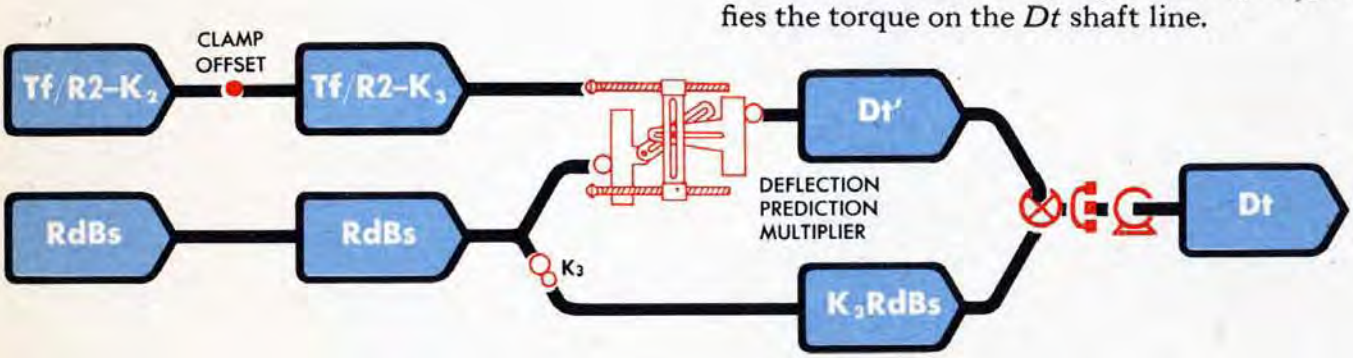
Without Wind or Initial Velocity corrections, *Ds* is made up of two Deflection quantities, *Dt* and *Dfs*. *Dt* is the Deflection Prediction for relative movement of Target and Own Ship during the Time of Flight. *Dfs* is the Drift Correction.

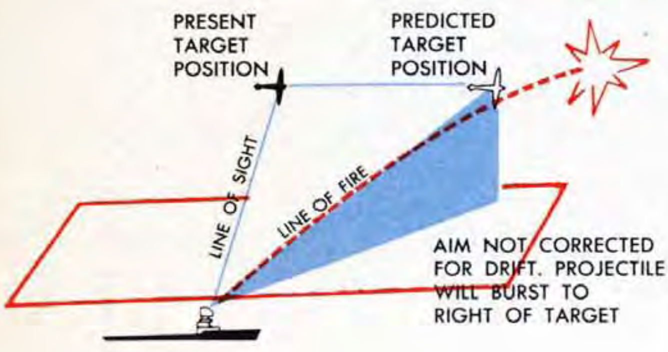
$$Ds = Dt - Dfs$$

Dt is computed by the Deflection Prediction Multiplier network.



The Deflection Prediction Multiplier multiplies Linear Deflection Rate, *RdBs*, by $Tf/R2 - K_3$, to obtain Dt'. $Tf/R2 - K_3$ is obtained by adding an offset constant K to $Tf/R2 - K_2$, the quantity used in the Elevation Prediction Multiplier. The quantity K_3 offsets the lead screw input to the Deflection Prediction Multiplier and causes an error in the multiplier output. To correct this error, a branch of the *RdBs* line is multiplied by a constant K_3 through a gear ratio, to produce a correction quantity K_3RdBs. K_3RdBs by-passes the multiplier and is added to Dt' in a differential to obtain *Dt*. A velocity-lag follow-up amplifies the torque on the *Dt* shaft line.



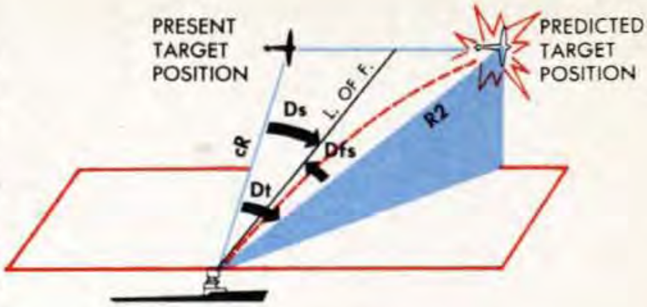


Drift

In order to prevent projectiles from turning end over end in flight, guns are rifled to rotate or spin the projectiles. The rifling in the gun barrels causes the projectiles to spin clockwise. This spin causes the projectile path to curve to the right. Guns must therefore be trained to the left of the Predicted Target Position to compensate for the curve.

Drift Correction, *Dfs*

It has been found that the average correction needed to compensate for drift is approximately proportional to the Elevation Correction, $Vf + Pe$, when $I.V.$ is 2550 f.s. $Vf + Pe$ from the $Vf + Pe$ Ballistic Computer is converted to Drift Correction, Dfs, by a gear ratio on a branch of the $Vf + Pe$ shaft line.

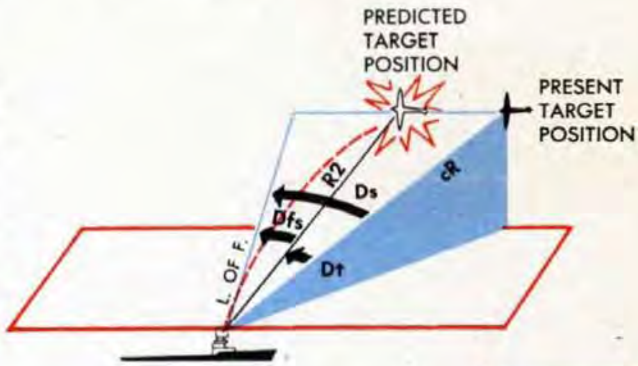


Dfs is subtracted from Dt at a differential to obtain Sight Deflection, Ds.

$$Ds = Dt - Dfs$$

When Dt is positive, which it is when the Target is deflecting to the right of the Line of Sight, Dfs, will make Ds less positive than Dt.

When Dt is negative, which it is when the Target is deflecting to the left of the Line of Sight, Dfs will make Ds more negative than Dt.

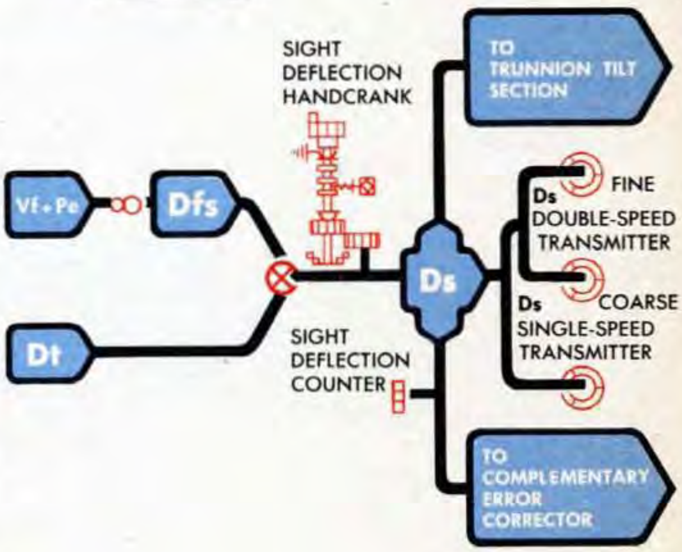


Where *Ds* is used

Ds goes to the Trunnion Tilt Section, where it is used in computing the Gun Orders.

Ds also positions the two Sight Deflection Transmitters, one of which is a double-speed transmitter and the other a single-speed transmitter. Both transmitters send Ds to the guns to offset the gun sights in Deflection.

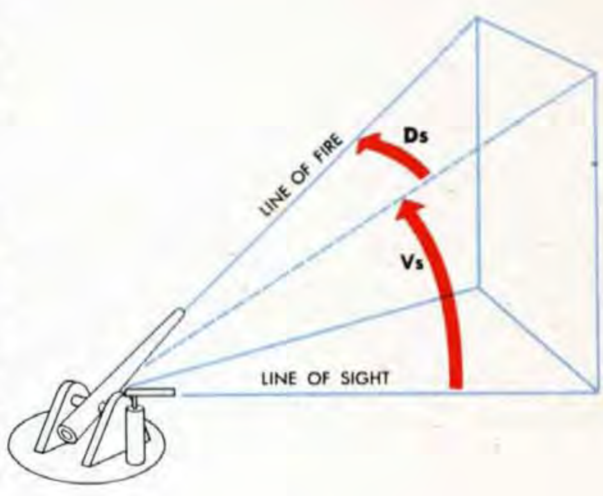
Ds goes also to the Complementary Error Corrector in the Elevation Prediction Section.



Using *Vs* and *Ds* at the Guns

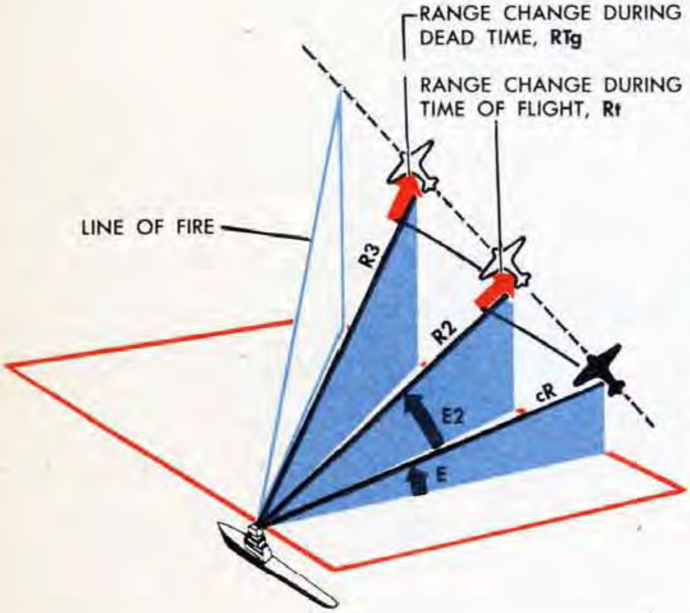
When Gun Elevation Order, $E'g$, and Gun Train Order, $B'gr$, are used to position the guns, the gun sights are offset from the guns by Sight Angle, Vs, and Sight Deflection, Ds. Thus, the observer at the gun may view the Target through the gun sight.

Vs and Ds may also be used in firing against surface targets when Gun Orders $B'gr$ and $E'g$ are not available. With the gun sights offset by Vs and Ds, moving the gun to bring the sights onto the Target will elevate and train the gun to the correct Line of Fire.



If some of the Computer's transmission circuits are not energized, but the circuits for the Sight Deflection Transmitters are energized, these transmitters may be set by hand according to any information available. This is done by turning the Sight Deflection Handcrank in the IN position and watching the Sight Deflection Counter. The handcrank and counter are on the rear top of the Computer.

COMPUTING FUZE SETTING ORDER, F



The fuze of a projectile must be set so that the projectile will burst at the end of a given time interval after it is fired. The projectile must be timed to burst at the Predicted Target Position.

Fuze Setting Order, *F*, is the computed fuze time, in seconds, at which the fuze must be set.

If a projectile fuze could be set in the gun at the instant the projectile is fired, the Fuze Setting Order would equal Time of Flight, *Tf*. But since fuzes must be set several seconds before firing, in a separate Fuze Setter, the fuze time will be different from Time of Flight.

The changes in Target Position taking place during the time between setting the fuze and firing the fuzed projectile must be considered. The time between the setting of the fuze and the firing of the projectile is called *Dead Time*. Dead Time usually varies from 2½ to 5 seconds, depending on the skill of the gun crew and other factors, and is determined by ship's doctrine. The value needed for setting the fuze is the value that Time of Flight will have at the end of Dead Time. The value of Time of Flight at the end of Dead Time depends on the values Advance Range and Predicted Target Elevation will have at the end of Dead Time.

It has been found that the change in *E2* during Dead Time is usually small. The Computer Mark 1 therefore computes no new value of Predicted Target Elevation. The principal change in Target Position during Dead Time occurs in Advance Range, *R2*. A new quantity, Fuze Range, *R3*, must be computed. Fuze Range, *R3*, is the approximate value that Advance Range, *R2*, will have at the end of Dead Time. *R3* is calculated by computing the linear Range Change during Dead Time, *RTg*, and adding *RTg* to the present value of Advance Range, *R2*.

$$R3 = R2 + RTg$$

RTg is computed in the Dead Time Prediction Multiplier.

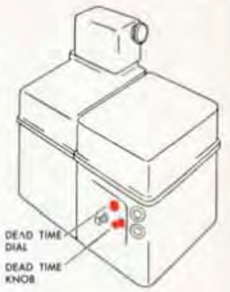
R3 and *E2* are used in the Fuze Ballistic Computer to obtain Fuze Setting Order, *F*.

The dead time prediction multiplier

The inputs to the Dead Time Prediction Multiplier are Direct Range Rate, dR, and Dead Time, Tg. The output is Range Change during Dead Time, RTg.

$$RTg = dR \times Tg$$

The value of Dead Time is determined by each ship for its particular gun crews. It is set into the Computer manually by turning the Dead Time Knob on the left side of the lower front section of the Computer Mark 1. RTg is added to $R2$ at a differential. The differential output is Fuze Range, $R3$.

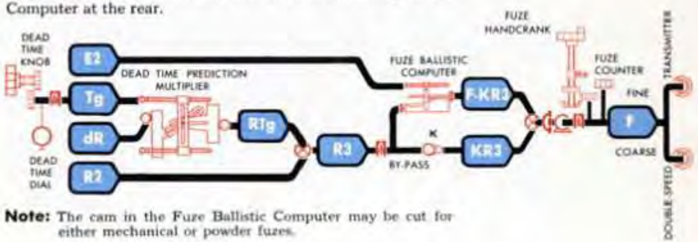


The fuze ballistic computer

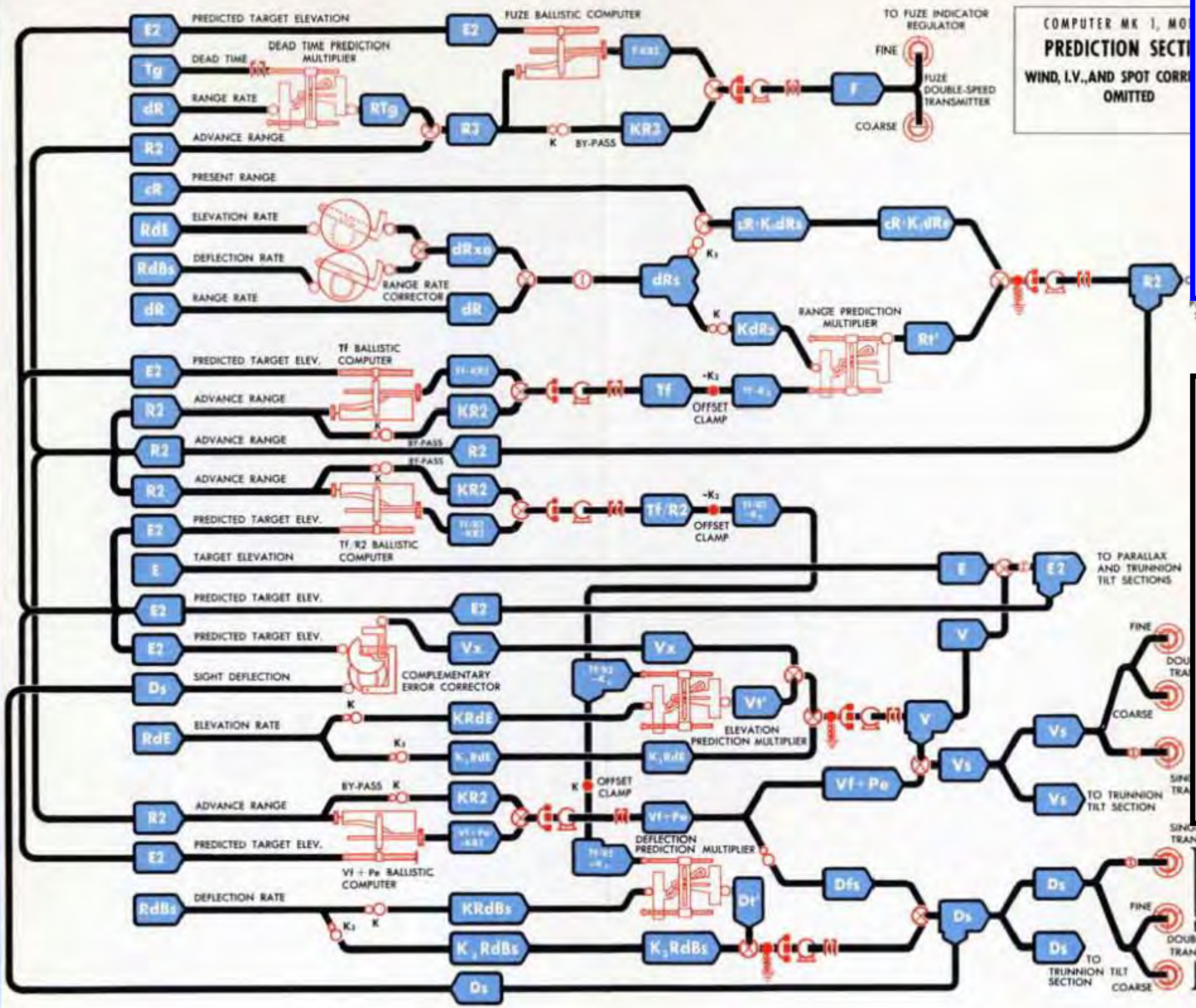
Fuze Range, $R3$, positions the cam in the Fuze Ballistic Computer. Predicted Elevation, $E2$, positions the cam follower. The cam computes the difference between Fuze Setting Order, F, and a straight-line approximation of F, called $KR3$. The cam output is $F - KR3$.

A branch of the $R3$ line by-passes the cam. A gear ratio on this line produces $KR3$. $KR3$ is added to the cam output, $F - KR3$, at a differential to obtain Fuze Setting Order, F. F is amplified by a velocity-lag follow-up which positions the Fuze Setting Order Transmitter. The Fuze Setting Order Transmitter is a double-speed transmitter.

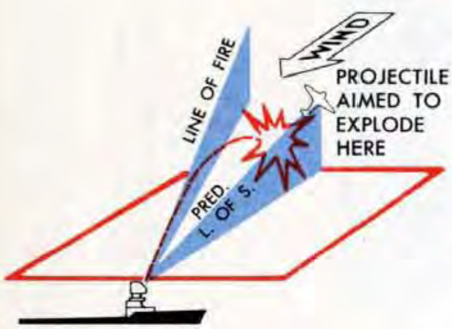
If for any reason some of the Computer's transmission circuits are not energized, but the circuit for the Fuze Setting Order Transmitter *is* energized, the transmitter may be set by hand according to any information available. This is done by turning the Fuze Handcrank in the IN position and watching the Fuze Counter. The handcrank and counter are on top of the Computer at the rear.



Note: The cam in the Fuze Ballistic Computer may be cut for either mechanical or powder fuzes.

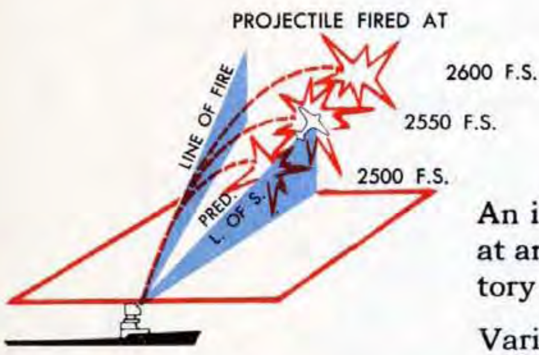


How Vs, Ds, and F are corrected to allow for WIND and change in INITIAL VELOCITY



Up to this point the three prediction quantities, *Vs*, *Ds*, and *F*, have been computed for a problem where no Wind is blowing and where all projectiles are being fired at an Initial Velocity of 2550 f.s. These conditions seldom exist in actual operation. Allowances for the effect of Wind and changes in Initial Velocity are therefore included in the predictions.

Wind may change the normal trajectory of a projectile in several ways. Its effect depends on the strength of the Wind and the direction from which it is blowing.



An increase or decrease in the Initial Velocity of a projectile, at any given gun elevation, will lengthen or shorten the trajectory of a projectile.

Variations in trajectory which may be caused by Wind and changes in Initial Velocity are not included on the cams of the four ballistic computers in the Prediction Section. The ballistic data cut onto these cams is based on the trajectory a projectile will follow when there is no Wind and Initial Velocity is 2550 f.s. The cam outputs must be corrected for the effects of Wind and changes in Initial Velocity.

The cam outputs are corrected by altering the values of the two cam inputs, *R2* and *E2*. The alterations of *R2* and *E2* are based on *I.V.* inputs and on three computed Wind Rates. The amounts that *R2* and *E2* are altered are computed through mechanism equations. Mechanism equations are shortcut approximations of the true equations. Constants are used in mechanism equations in such a way that these equations can be solved through use of gear ratios, clamps, and mechanisms that are already in the computer for other purposes.

The alterations of *R2* and *E2* change the ballistic cam outputs. These changes help to correct *Vs*, *Ds*, and *F* for the effects of Wind and any deviation in *I.V.* from 2550 f.s. Further corrections for these effects are necessary and will be described in turn.

How wind may affect trajectory

Wind is always considered to be blowing in the *horizontal* plane. Depending on the direction from which the Wind is blowing and the Target Elevation, a projectile that would normally hit a Target may be affected in several ways.

If the Target is at a low Elevation and the Wind is blowing along the plane of the Line of Fire against the projectile, the projectile will burst short of the Target. To compensate for this, the computations must be based on a longer Range.

Under the same conditions, if the Wind is blowing with the projectile, the projectile bursts beyond the Target. To compensate for this, the computations must be based on a shorter Range.

If the Wind is blowing from the right at 90° to the Line of Fire, the projectile will burst to the left of the Target. To compensate for this the gun must be trained to the right.

If the Wind is blowing from the left at 90° to the Line of Fire, the projectile will burst to the right of the Target. The gun must be trained to the left.

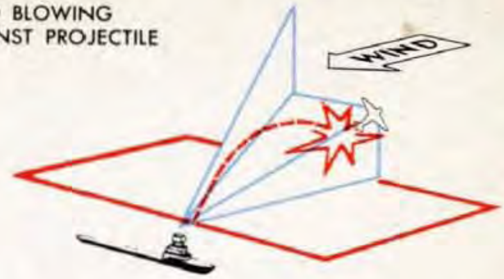
If the Target is at a high elevation and the Wind is blowing against the projectile along the plane through the Line of Fire, the Wind effect will tend to elevate the trajectory. To correct for this, the Elevation of the gun must be reduced.

Under the same conditions, if the Wind is blowing with the projectile, the Wind effect will tend to depress the trajectory. To correct for this, the Elevation of the gun must be increased.

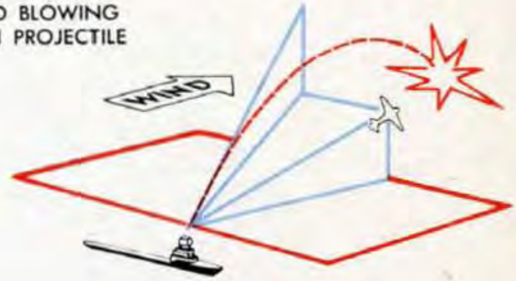
The examples given here are special cases. Normally the Wind does not blow exactly along or at right angles to the plane of the Line of Fire, but has COMPONENTS in, or at right angles to, the plane through the Line of Fire.

The Wind effect on the Range, Elevation, and Deflection Predictions is found by computing the components of Wind in three directions: along the Line of Fire for Range, at right angles to the Line of Fire in the vertical plane for Elevation, and at right angles to the Line of Fire in the horizontal plane for Deflection.

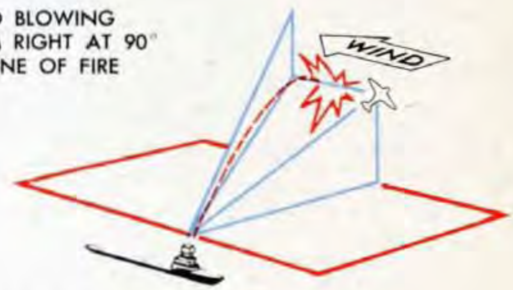
WIND BLOWING AGAINST PROJECTILE



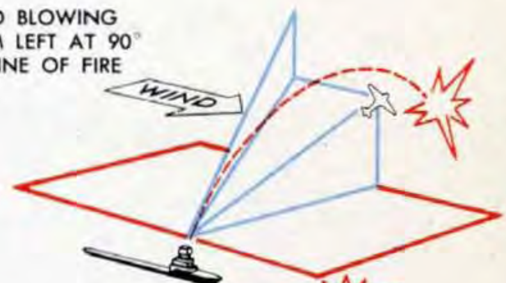
WIND BLOWING WITH PROJECTILE



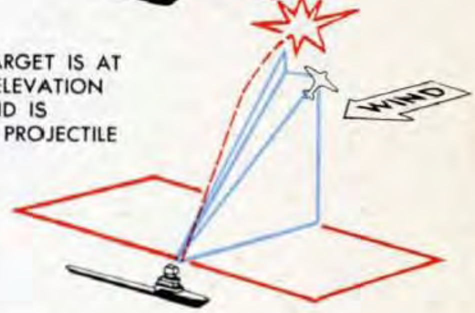
WIND BLOWING FROM RIGHT AT 90° TO LINE OF FIRE



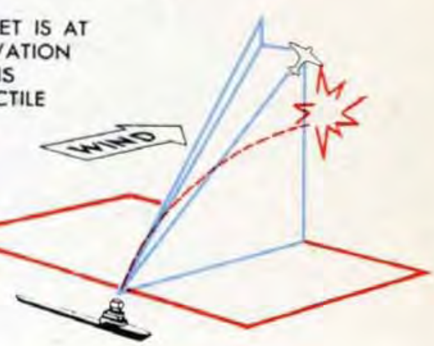
WIND BLOWING FROM LEFT AT 90° TO LINE OF FIRE



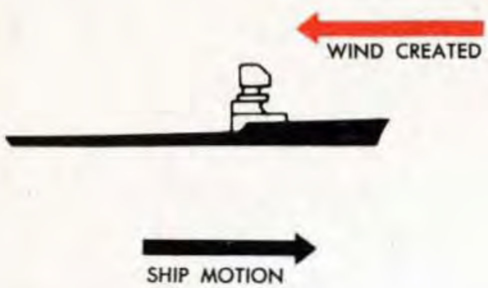
WHEN TARGET IS AT A HIGH ELEVATION AND WIND IS AGAINST PROJECTILE



WHEN TARGET IS AT A HIGH ELEVATION AND WIND IS WITH PROJECTILE

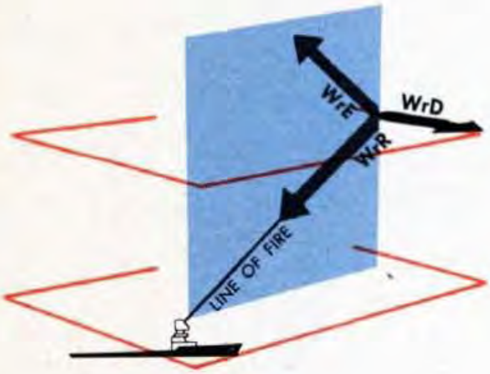


COMPUTING WIND RATES



Even when there is no wind the motion of Own Ship creates wind which can be felt on the moving ship. This wind caused by Own Ship Motion has the same speed as Own Ship Speed and a direction opposite to Own Ship Course.

A projectile fired from a ship in motion retains the ship's motion during its flight, and, in effect, a wind due to this motion will blow against the projectile.



When the True Wind is blowing, the trajectory of a projectile will be affected by both the True Wind and the Wind caused by Own Ship Motion. True Wind and Wind caused by Own Ship Motion must be combined to obtain the APPARENT WIND, the wind acting on the projectile. This is done by finding two components of True Wind and two components of Wind caused by Own Ship Motion. The components in the same directions are combined to obtain two components of Apparent Wind.

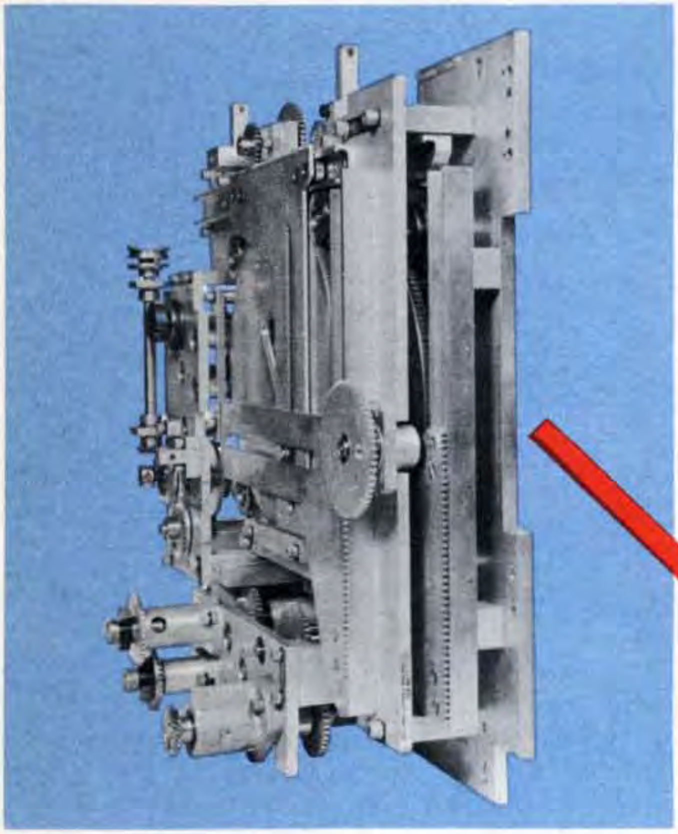
One component of Apparent Wind, at right angles to the plane of fire, is the Wind Rate affecting Deflection Prediction, *WrD*. The other component of Apparent Wind, in the plane of fire, is used in computing the other two Wind Rates:

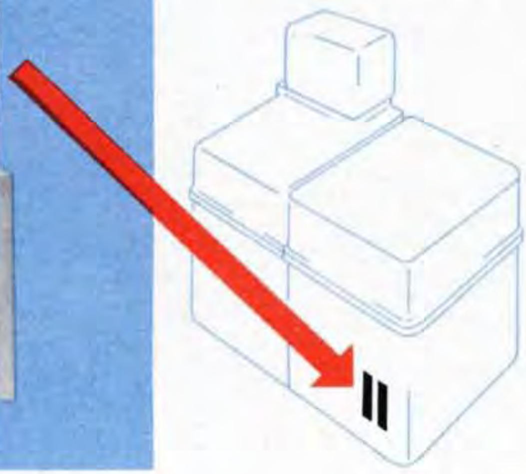
The Wind Rate affecting Range Prediction, *WrR*.

The Wind Rate affecting Elevation Prediction, *WrE*.

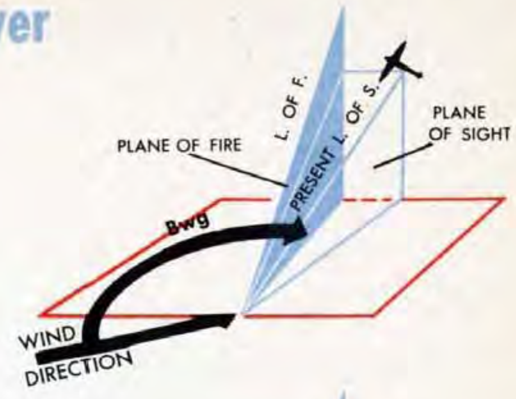
Two Wind Component Solvers and the Own Ship Component Solver are used in computing the Wind Rates.

The two Wind Component Solvers are in the lower front section of the Computer Mark 1.





The horizontal wind component solver



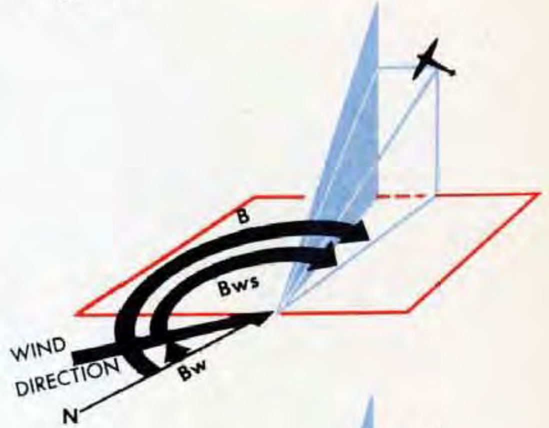
The Horizontal Wind Component Solver is a cam-type component solver. Its two inputs are:

True Wind Speed, *Sw*, which positions the cam.

Predicted Wind Angle, *Bwg*, which positions the vector gear.

True Wind Speed, *Sw*, is put into the Computer Mark 1 manually by turning the Wind Speed Handcrank to set the Wind Speed Dial.

Predicted Wind Angle, *Bwg*, is the angle between the direction from which the wind is blowing and the vertical plane approximately through the Line of Fire, measured in the horizontal plane clockwise from the direction from which the wind is blowing.

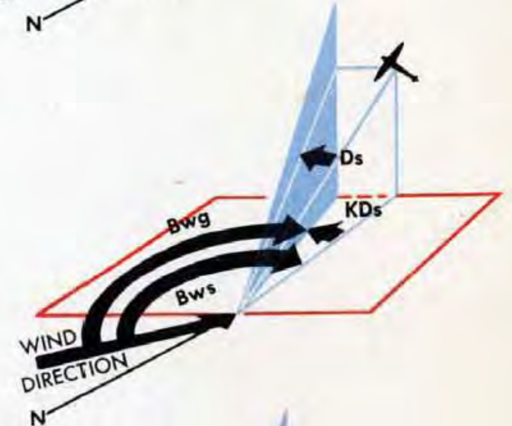


Bwg is computed as follows: First, Wind Direction, *Bw*, is subtracted from True Target Bearing, *B*, to obtain Wind Angle, *Bws*. Wind Direction, *Bw*, is the horizontal angle between the North-South vertical plane and the direction from which the wind is blowing. *Bw* is put into the Computer manually at the Wind Direction Handcrank. *Bws* is the horizontal angle between the direction from which the wind is blowing and the vertical plane through the Line of Sight. $B - Bw = Bws$.

Sight Deflection, *Ds*, is then multiplied by a constant, *K*, and is added to Wind Angle, *Bws*, to obtain *Bwg*.

$$Bws + KDs = Bwg$$

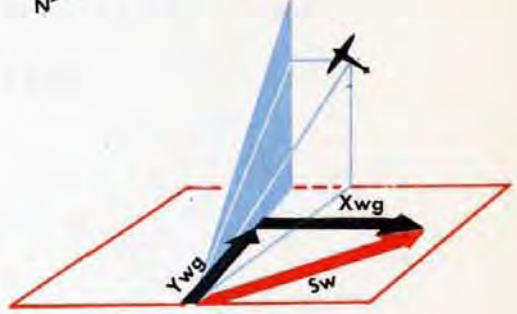
If *KDs* is a minus value, the equation for *Bwg* is: $Bwg = Bws + (-KDs)$.

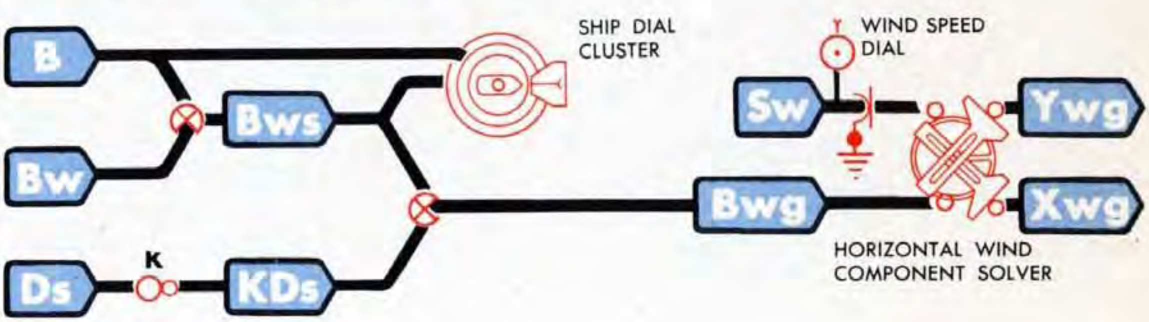


Sight Deflection, *Ds*, is the Deflection angle between the vertical plane through the Line of Sight and the vertical plane through the axis of the gun. *Ds* is measured in a slant plane perpendicular to the vertical plane through the Line of Sight. Multiplying *Ds* by the constant *K* approximately refers *Ds* from its slant plane to the horizontal plane.

The outputs of the Horizontal Wind Component Solver are two components of True Wind Velocity:

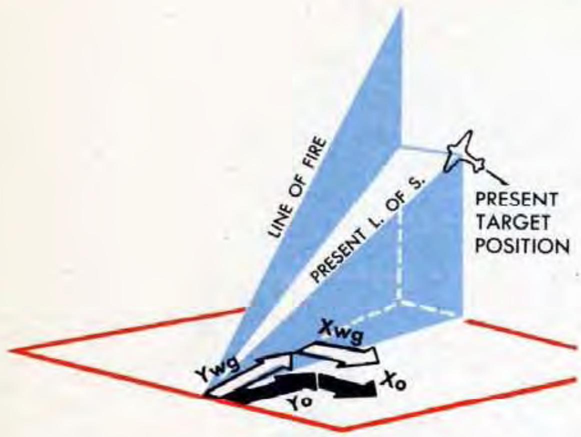
1. *Ywg*, the horizontal range component of True Wind Velocity in the vertical plane approximately through the Line of Fire.
2. *Xwg*, the horizontal deflection component of True Wind Velocity perpendicular to the vertical plane approximately through the Line of Fire.



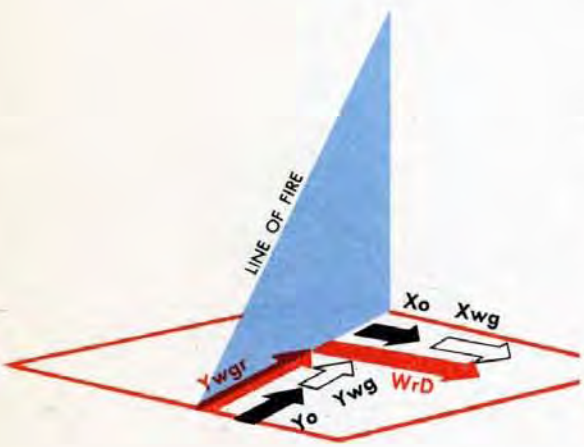


How components of apparent wind are computed

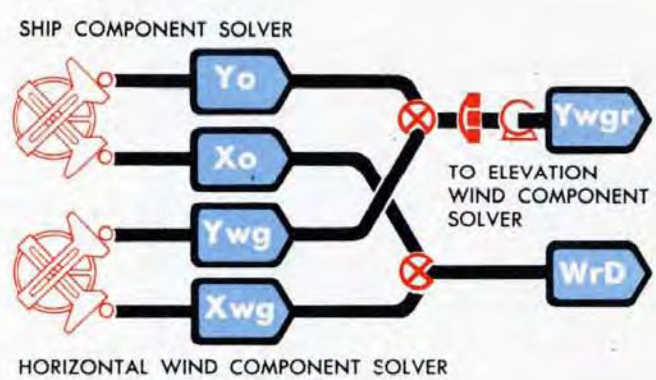
Wind caused by Own Ship Motion is equal to Own Ship Speed; therefore the two components of Own Ship Velocity, *Xo* and *Yo*, reversed in sign, are used as the two components of Wind caused by Own Ship Motion.



Xo and *Yo* lie in and at right angles to the vertical plane containing the LINE OF SIGHT, while *Xwg* and *Ywg*, the components of True Wind Velocity, lie in and at right angles to the vertical plane containing the LINE OF FIRE. To avoid use of additional mechanisms in computing Wind effects, *Xo* and *Yo* are used as approximations of components of Own Ship Motion relative to the plane of the Line of Fire. Since the angle between the planes of sight and fire is usually small, the error involved may be disregarded.



Xo is combined with *Xwg* to obtain *WrD*, the horizontal component of Apparent Wind Velocity at right angles to the vertical plane containing the Line of Fire. *Yo* is combined with *Ywg* to obtain *Ywgr*, the horizontal component of Apparent Wind Velocity in the plane of the Line of Fire.



WrD is the component of Apparent Wind Velocity affecting Deflection Prediction. It is called the Deflection Wind Rate and is one of the three Wind Rates needed in Prediction.

Ywgr is the horizontal component of Apparent Wind Velocity in the vertical plane of fire. *Ywgr* is not a final Wind Rate, but is used to compute the components of Apparent Wind Velocity affecting Range and Elevation Predictions, which are the two other Wind Rates.

NOTE:
Ballistic Wind values are substituted for True Wind values when prescribed by *ship's doctrine*. In this case the Computer corrects for Apparent Ballistic Wind.

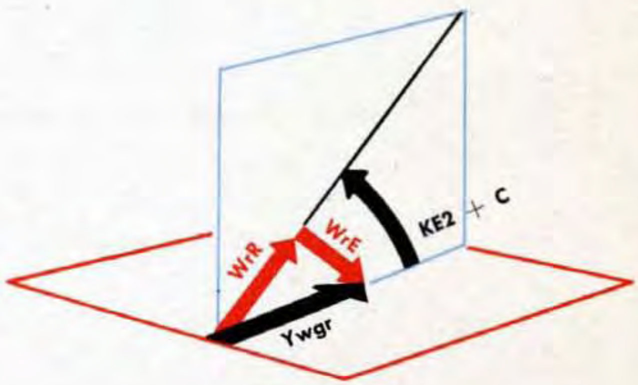
The elevation wind component solver

The Elevation Wind Component Solver is a screw-type component solver.

The two inputs are $Ywgr$, which positions the screw, and $KE2 + C$, which positions the vector gear.

$KE2 + C$ is an empirical quantity which gives the best average results for all problems.

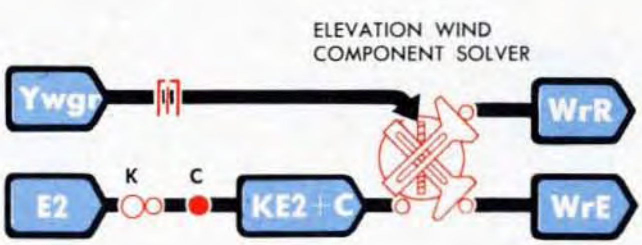
$KE2 + C$ is computed as follows: Predicted Target Elevation, $E2$, is multiplied in a gear ratio by a constant, K, to obtain $KE2$. Constant C is offset at a clamp on the $E2$ shaft line to obtain $KE2 + C$.



The Elevation Wind Component Solver computes two components of $Ywgr$:

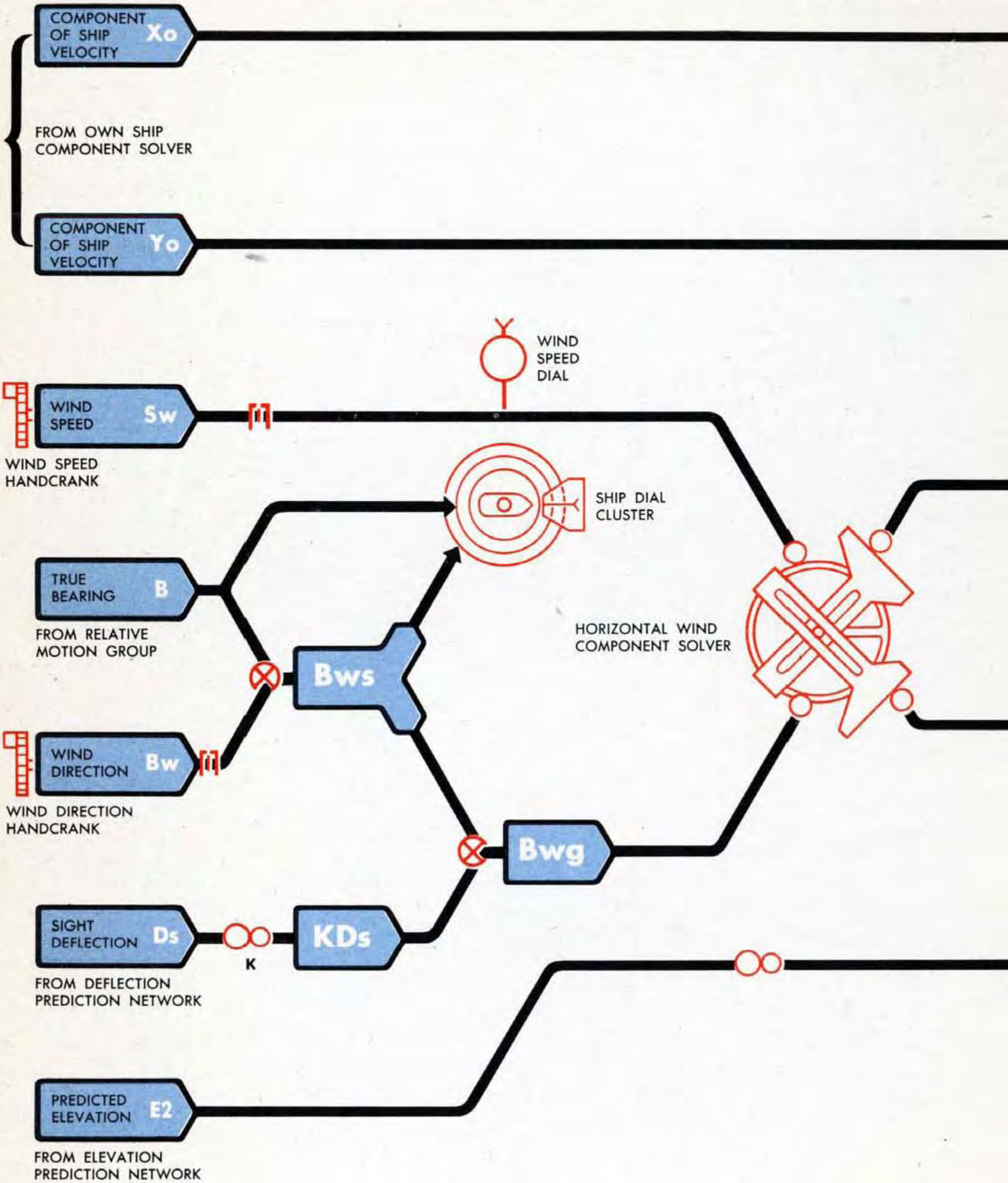
1 The component of Apparent Wind Velocity affecting Range Prediction is the Range Wind Rate, WrR.

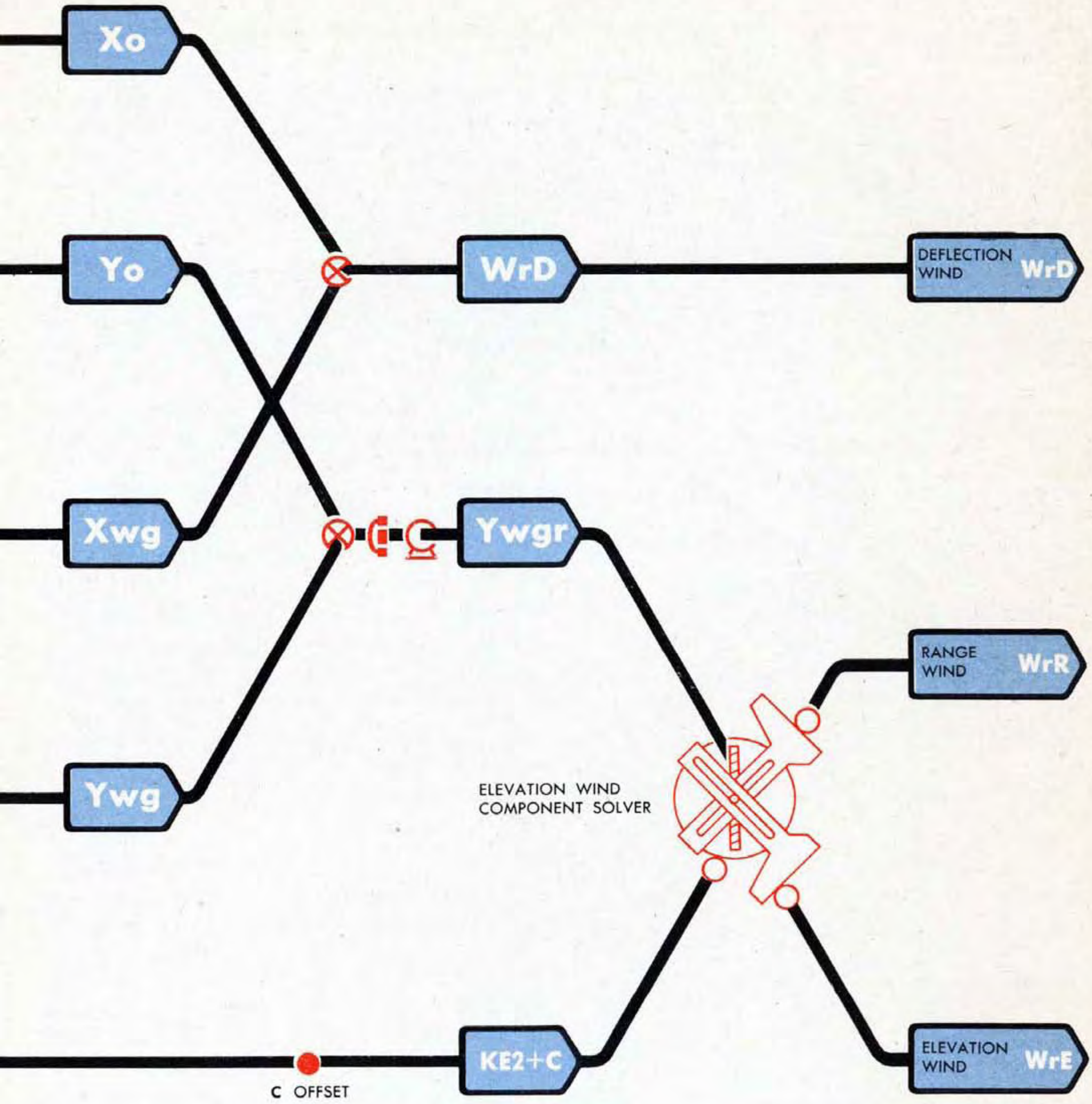
2 The component of Apparent Wind Velocity affecting Elevation Prediction, is the Elevation Wind Rate, WrE.



The three Wind Rates, WrR, WrE, and WrD are used to adjust the Range, Elevation, and Deflection Predictions for the effect of Wind.

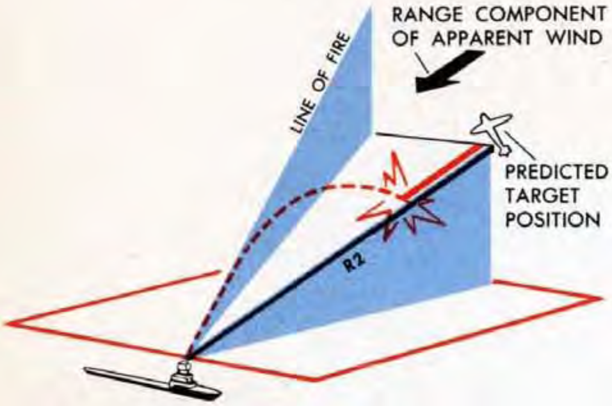
SCHEMATIC of the WIND RATES





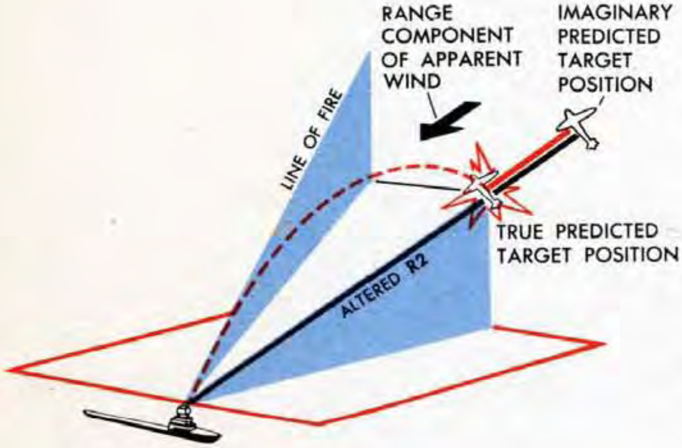
Xo
Yo
Xwg
Ywg
WrD
Ywgr
KE2+C
C OFFSET
ELEVATION WIND
COMPONENT SOLVER
DEFLECTION WIND WrD
RANGE WIND WrR
ELEVATION WIND WrE

Changing R2 to allow for WIND



The amount by which $R2$ must be altered to allow for the effect of wind depends on:

1. The value of the Range Wind Rate, WrR, and
2. The length of time the wind blows on the projectile, that is, Time of Flight, Tf.



The effect of Range Wind on a projectile can be seen by studying a problem in which a wind is blowing against a projectile along the Line of Fire. Assume that this wind, by blowing against the projectile during its Time of Flight, will cause the projectile to burst short of the Target.

If Advance Range, $R2$, is now increased to an imaginary Predicted Target Position, a projectile fired using this imaginary $R2$ will travel to the Target's true Predicted Position.

The change of Range to allow for Wind is made by increasing or decreasing Advance Range, $R2$, depending on the direction of the Wind component.

In the Computer Mark 1, Advance Range, $R2$, is altered by increasing or decreasing the linear output of the Range Prediction Multiplier by a computed amount. The amount that the multiplier output must be increased or decreased is Rw, Linear Range Prediction to compensate for Wind effect. Range Wind Rate, WrR, is needed in the mechanism equation used to obtain Rw. This equation is:

$$Rw = K_1 WrR\ (Tf - K_2)$$

WrR from the Elevation Wind Component Solver is multiplied by K_1 by means of a gear ratio. The remainder of this equation is solved in the Range Prediction Multiplier. Rw does not exist as a separate quantity but is included in the multiplier output.

The range prediction multiplier does two jobs at once

The Range Prediction Multiplier multiplies Prediction Range Rate, *dRs*, by Time of Flight, *Tf*, to produce the Range Prediction, *Rt*.

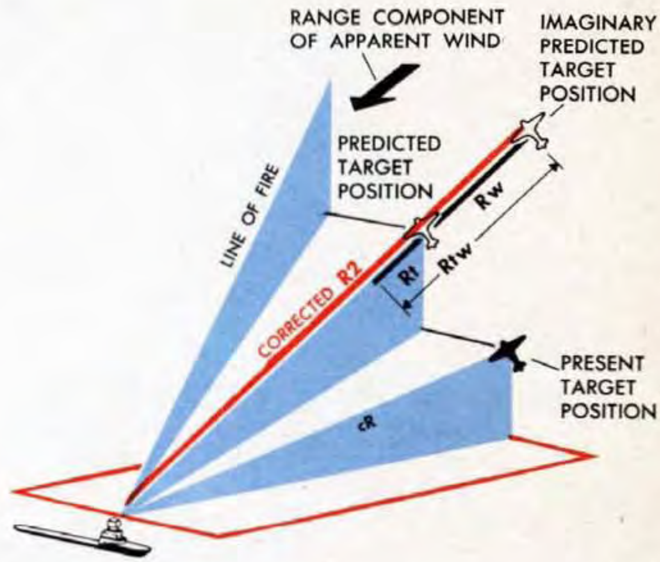
$$Rt = dRs \times Tf$$

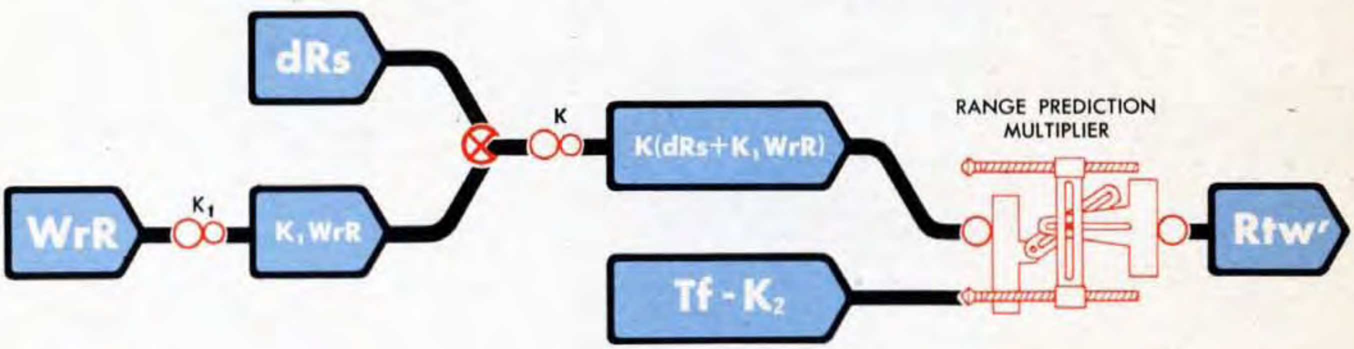
The same multiplier also multiplies K_1WrR by $Tf - K_2$. These two computations are made in the same multiplier to save mechanisms. K_1WrR is added to dRs to obtain $dRs + K_1WrR$. The quantity $dRs + K_1WrR$ is then multiplied by the constant K in a gear ratio to obtain the quantity:

$$K\ (dRs + K_1WrR)$$

In the Range Prediction Multiplier, $K\ (dRs + K_1WrR)$ is multiplied by $Tf - K_2$ to obtain Rtw'.

$$K\ (dRs + K_1WrR) \times (Tf - K_2) = Rtw'$$





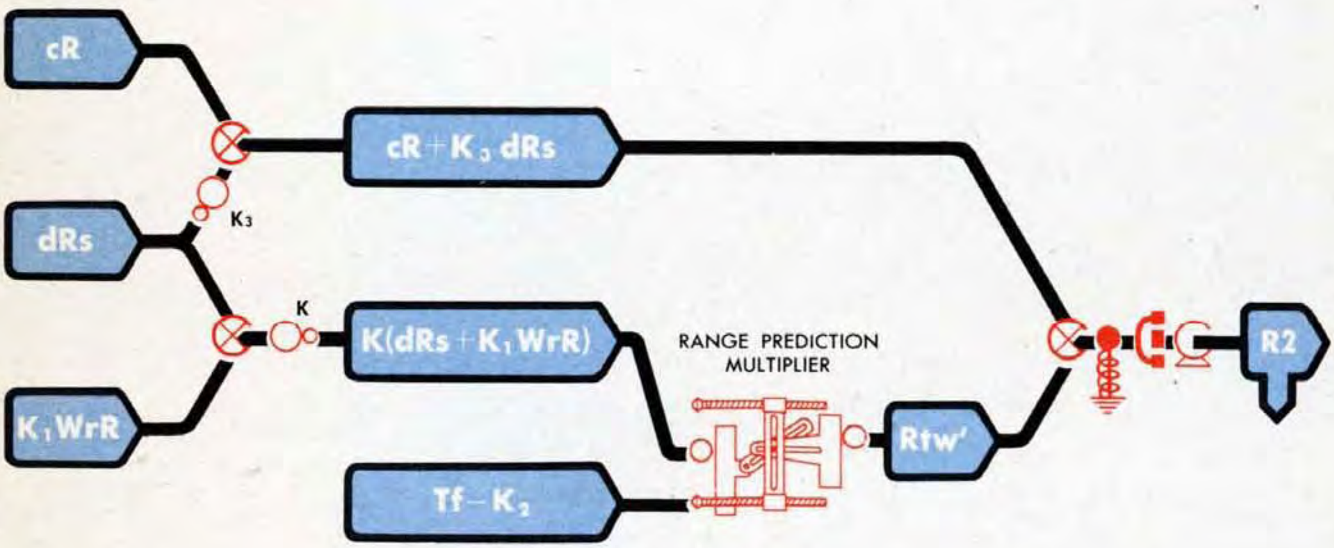
K is a constant used to change knots to yards per second. K_2 is required for computing Rw. Because only one multiplier is used instead of two, dRs is also multiplied by K_2. This means that the output of the multiplier will be Rtw' ($= Rt' + Rw$) instead of Rtw. (See NOTE on page 266.) The necessary correction is applied by a branch of the dRs line which bypasses the multiplier.

The range prediction multiplier by-pass

The constant K_2, which is introduced into the equation for Rtw', is needed to produce Rw, but is not needed to produce a correct value of Rt. Since dRs, as well as WrR, is multiplied by this constant, K_2, the Range Prediction Multiplier output, Rtw', contains an error, $(-K \cdot K_2 \cdot dRs)$. This error in Rtw' is cancelled by the K_3dRs by-pass. K_3dRs is first added to cR. Then the sum of cR and K_3dRs is added to Rtw' to obtain $R2$.

$$Rtw' + cR + K_3dRs = R2,$$

where $K_3 = K \times K_2$.



WHEN THE VALUE OF *R2* HAS BEEN ALTERED TO COMPENSATE FOR WIND, *R2* NO LONGER REPRESENTS THE DISTANCE FROM OWN SHIP TO THE TRUE PREDICTED TARGET POSITION. IT IS THE ADVANCE RANGE TO AN *IMAGINARY* PREDICTED TARGET POSITION.

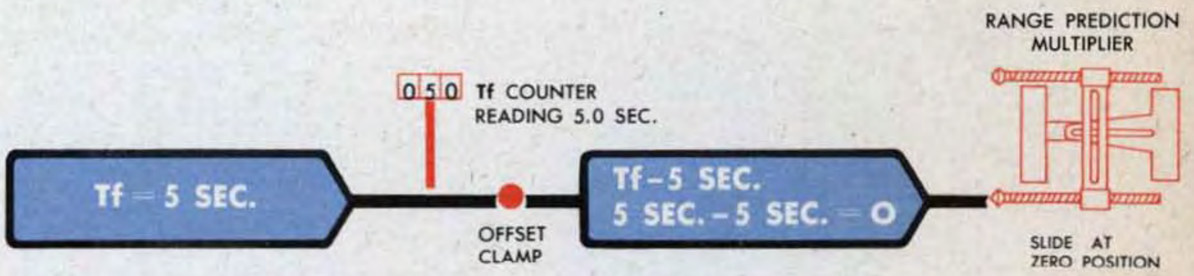
How the multiplier input is changed from Tf to Tf−K_2

K_2 is an offset.

The value of this constant, K_2, is 5 seconds.

In order to produce a value of $Tf - 5$ for every input of Tf, the multiplier slide is set so that it is at its zero position when the Tf Counter reads 5 seconds.

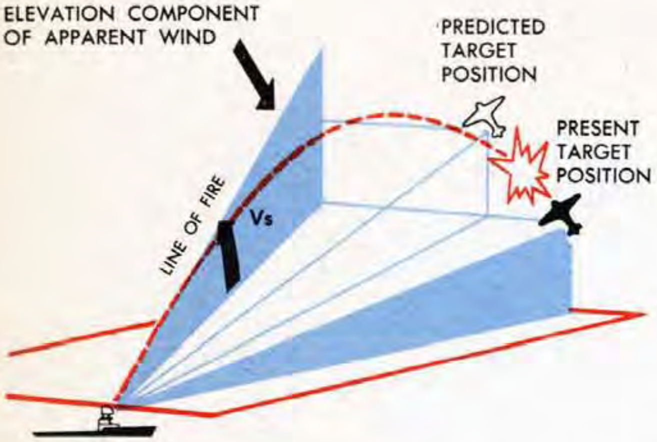
The position of the slide always represents five seconds less than the value of Tf, and causes the second input to be multiplied by $Tf - K_2$.

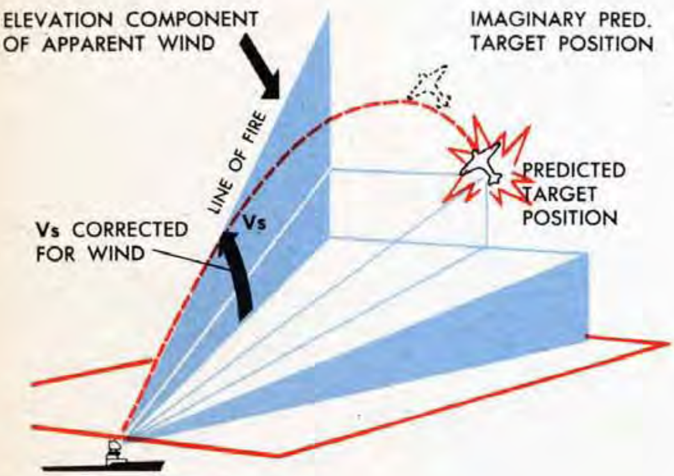


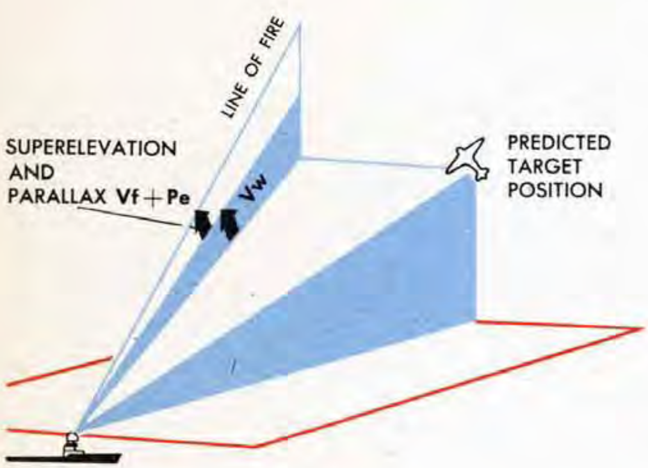
Correcting F to allow for wind

Since the altered value of $R2$ is used in the Fuze network, the value of Fuze Setting Order, F, contains an allowance for Wind.

Correcting Vs to allow for WIND







The effect of the Elevation Wind on a projectile can be seen by studying a problem where the wind is blowing at right angles to the Line of Fire, in the vertical plane through the Line of Fire. Assume that this wind would depress a projectile below its normal trajectory and cause it to burst below the Target.

If an imaginary Predicted Target Position is assumed above the True Predicted Target Position, and Vs is increased accordingly, a projectile fired using this Vs would be carried downward by the wind and would burst at the True Predicted Position.

The Elevation Correction for Wind is made therefore by decreasing or increasing Sight Angle, Vs.

In the Computer Mark 1, Sight Angle, Vs, is corrected for Wind by decreasing or increasing the output of the Elevation Prediction Multiplier by a computed amount. The angular amount that the multiplier output must be altered is Vw, Elevation Prediction to compensate for Wind. The Elevation Wind Rate, WrE, is used in the mechanism equation for Vw. The equation is:

$$Vw = K_1 WrE \times (Tf/R2 - K_2)$$

WrE is multiplied by K_1 by means of a gear ratio to produce K_1WrE. The quantity K_2 is introduced by an offset in the $Tf/R2$ line.

The value of $Tf/R2$ is affected by the constants used in the RANGE Prediction for Wind because the altered $R2$ is used in computing $Tf/R2$. The constants, K_1 and K_2, in the Vw equation are such that they supplement the Range constants, thereby completing the solution for Vw.

The quantity K_1WrE is multiplied by $Tf/R2 - K_2$ in the Elevation Prediction Multiplier. Vw does not exist as a separate quantity, but is part of the output of the Elevation Prediction Multiplier.

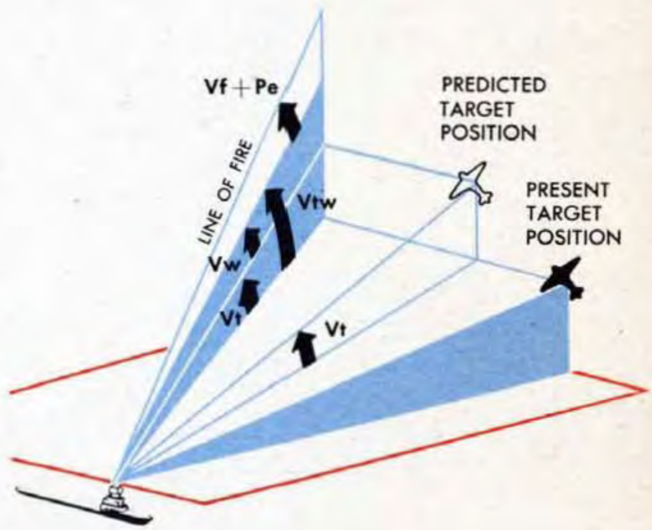
Vw alters $E2$ and $E2$ alters $R2$. These two quantities in turn alter all the Prediction quantities.

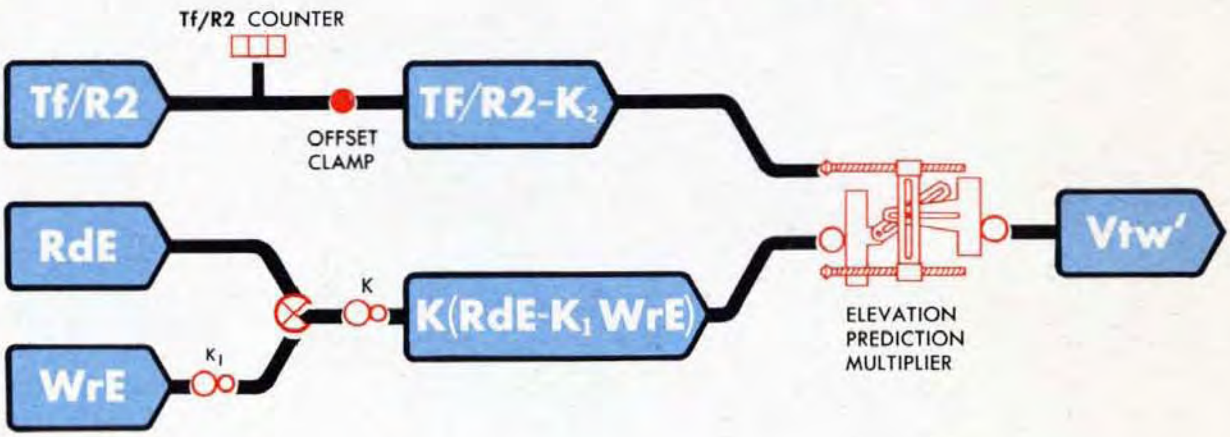
The elevation prediction multiplier

Linear Elevation Rate, *RdE*, is multiplied by $Tf/R2$ in the Elevation Prediction Multiplier to compute *Vt*, the Elevation Prediction to compensate for Relative Motion during the Time of Flight. Instead of using two multipliers, one to multiply *RdE* by $Tf/R2$ and another to multiply $K\,WrE$ by $Tf/R2 - K_2$, both of these computations are made in the Elevation Prediction Multiplier. K_1WrE is subtracted from *RdE* to obtain $RdE - K_1WrE$. $RdE - K_1WrE$ is then multiplied by a constant *K*, and $K(RdE - K_1WrE)$ is multiplied by $Tf/R2 - K_2$.

$$K(RdE - K\ WrE) \times (Tf/R2 - K_2) = Vtw'$$

The multiplier output, *Vtw'*, is the sum of *Vt'* and *Vw*. *Vt'* is an incorrect value of *Vt* for reasons explained in the note on page 266. The necessary correction is applied by means of the *RdE* by-pass.





The elevation prediction multiplier by-pass

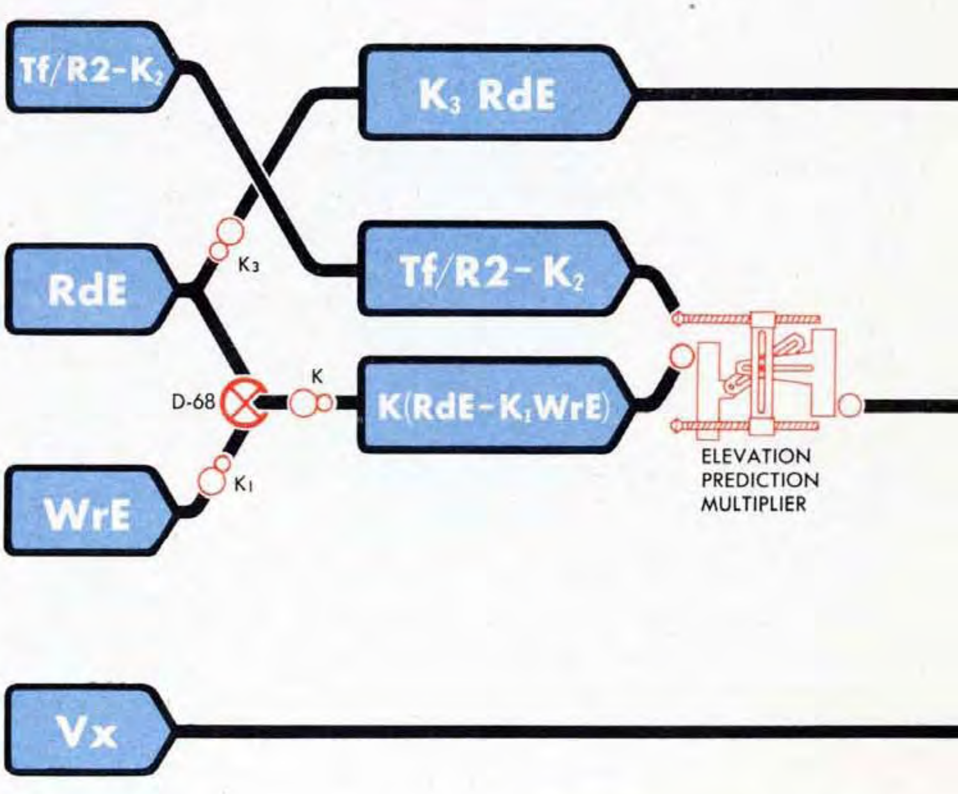
The constant K_2 which is introduced into the equation for solving Vtw is needed in producing an accurate value of Vw but is not needed to produce a correct Vt value. Since not only the Wind Rate, WrE, but also Linear Elevation Rate, RdE, is multiplied by this constant, the Elevation Prediction Multiplier output, Vtw', contains an error which is a function of RdE. This error in Vtw' is corrected by the K_3RdE by-pass.

The multiplier output, Vtw', is first combined with Complementary Error Correction, Vx, at differential D-70. Vtw' minus Vx is then corrected by adding K_3RdE at differential D-71. The output of differential D-71 is angular Elevation Prediction, V.

$$V = Vtw' - Vx + K_3RdE,$$

or

$$V = Vtw - Vx$$



Sight Angle, *Vs*, is corrected for the effect of the Elevation Wind Rate because Elevation Prediction, *V*, containing the Wind Correction, is used in computing *Vs*.

$$Vs = V + Vf + Pe$$

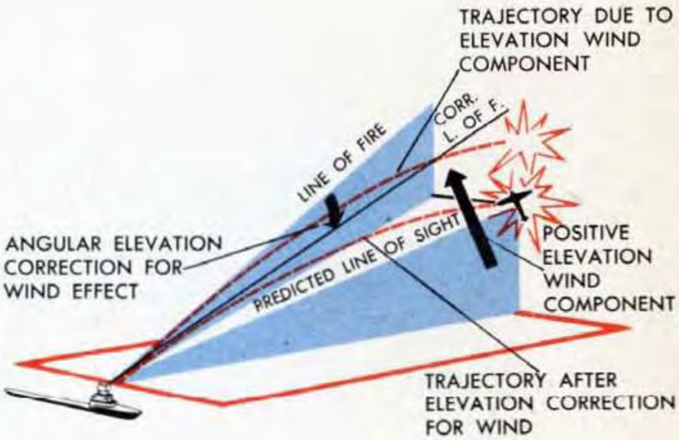
Predicted Target Elevation, *E2*, which is used as an input to the four ballistic computers, is also altered for the effect of the Elevation Wind Rate because the altered Elevation Prediction, *V*, is used in computing *E2*:

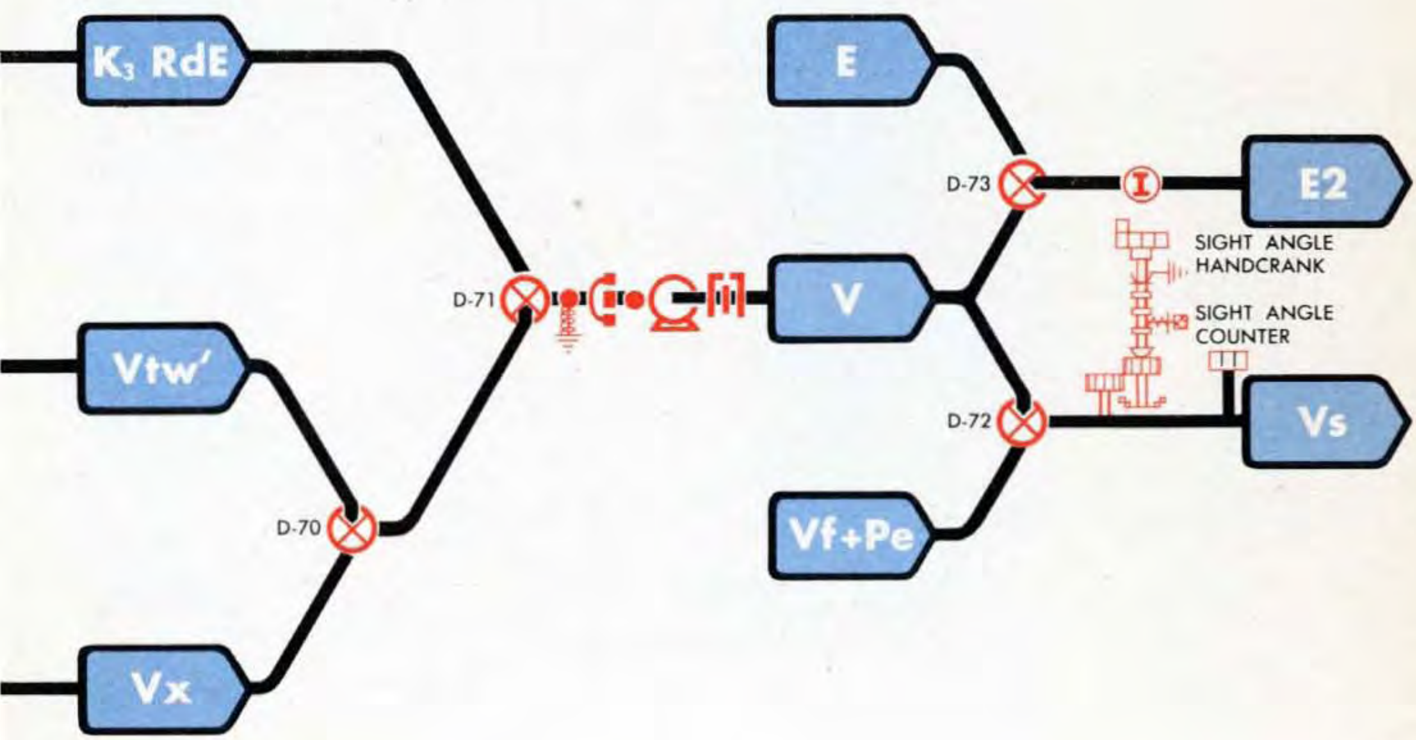
$$E2 = E + V$$

Why WrE is SUBTRACTED from RdE

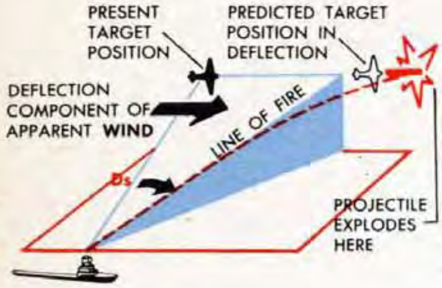
The Elevation Wind Rate is positive when the Wind is upward, since it tends to increase the Elevation of the projectile. The angular correction for a positive Elevation Wind Rate must reduce the Elevation. For this reason a positive Elevation Wind Rate, *WrE*, must be subtracted from the Elevation Rate, *RdE*, to reduce *Vs* and lower the Line of Fire.

When the Elevation Wind Rate is downward, it is a negative rate. This rate is still subtracted from *RdE*. Subtracting a negative value increases *Vs* and raises the Line of Fire.

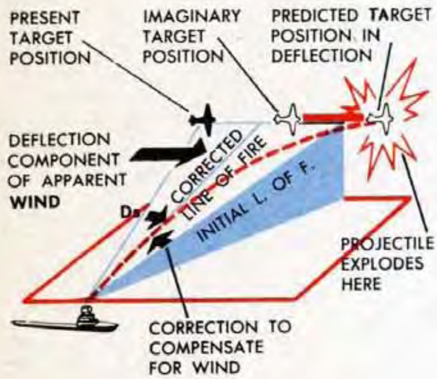




Correcting Ds to allow for WIND



The effect of the Deflection Wind Rate on a projectile can be seen by studying a problem where the Apparent Wind is coming from the left at right angles to the Line of Fire. This Wind would blow the projectile to the right, and would cause it to burst to the right of the Target.



If the Target's Predicted Position is assumed to be to the left of its True Predicted Position, and if Sight Deflection, *Ds*, is altered so that it is correct for this imaginary Predicted Target Position, a projectile fired using this value of *Ds* will burst at the True Predicted Target Position.

In the Computer Mark 1, the value of *Ds* is corrected for the effect of Wind by decreasing or increasing the output of the Deflection Prediction Multiplier by a computed amount. The angular amount by which the multiplier output must be altered is *Dw*, the Deflection Prediction to compensate for Wind. Deflection Wind Rate, *WrD*, is used in the mechanism equation for computing *Dw*. The equation used is:

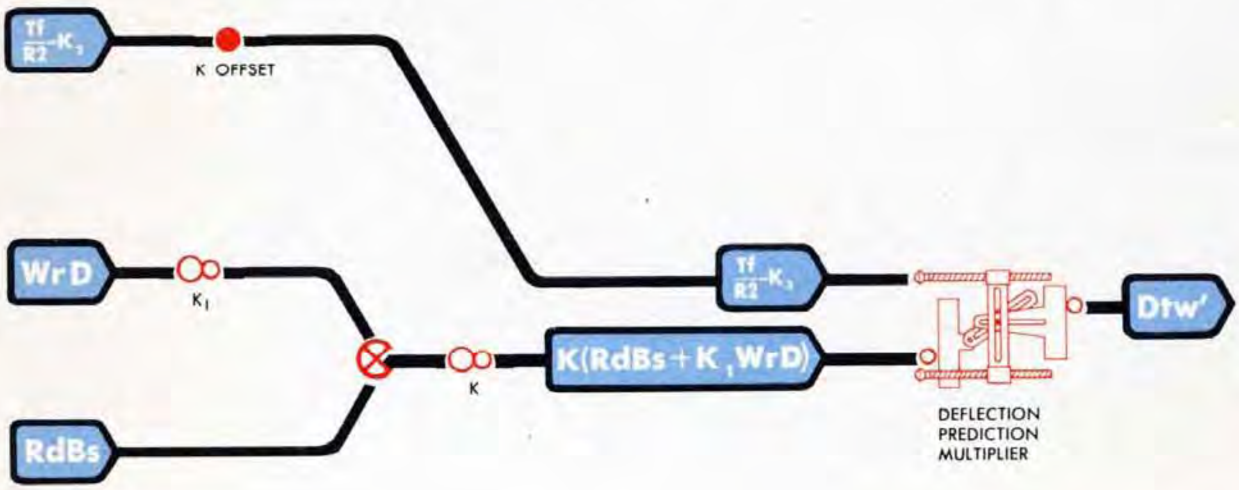
$$Dw = K_1 WrD \times (Tf/R2 - K_3)$$

WrD is multiplied by K_1 in a gear ratio to produce K_1WrD.

The quantity $Tf/R2 - K_2$, used in computing the Elevation Prediction for Wind, is offset by an additional constant to obtain $Tf/R2 - K_3$. Then K_1WrD is multiplied by $Tf/R2 - K_3$ in the Deflection Prediction Multiplier.

Like *Rw* and *Vw*, *Dw* does not exist as a separate quantity. *Dw* is part of the output of the Deflection Prediction Multiplier.

The constants K_1 and K_3 in the *Dw* equation supplement the changes already made to $Tf/R2$ by the Range and Elevation Wind Predictions and complete the solution for *Dw*.



The deflection prediction multiplier

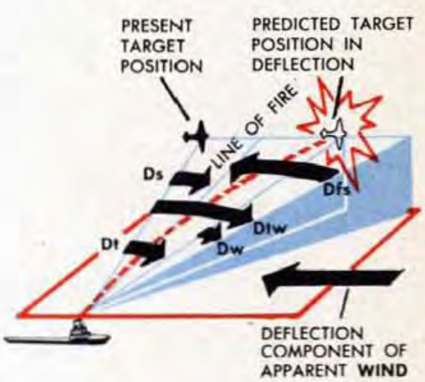
The output of the Deflection Prediction Multiplier is Dtw', the sum of Dt' and Dw. Dt' is the sum of Dt and an unwanted quantity. (See NOTE on page 266.) Dw is the Deflection Prediction for Wind.

K_1WrD is added to $RdBs$ to obtain $RdBs + K_1WrD$. $RdBs + K_1WrD$ is first multiplied by a constant, K, and is then multiplied by $Tf/R2 - K_3$ to produce Dtw'.

$$K(RdBs + K_1WrD) \times (Tf/R2 - K_3) = Dtw'$$

The unwanted quantity in Dtw' is $(-K_3RdBs)$. It is removed by a multiplier by-pass.

The multiplier by-pass



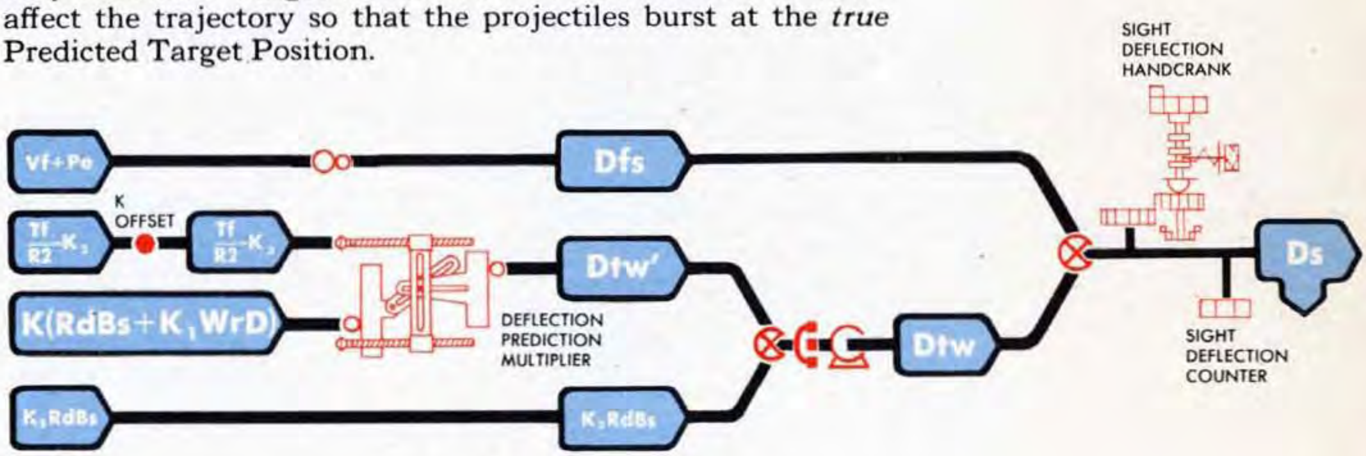
A branch of the $RdBs$ line is multiplied by K_4 at a gear ratio to produce K_4RdBs, the quantity used as the multiplier by-pass. K_4RdBs is added to the multiplier output Dtw', to obtain Dtw, the Deflection Prediction to compensate for Relative Motion and Wind.

$$Dtw' + K_4RdBs = Dtw$$

Dtw is amplified by a velocity-lag follow-up. Drift Correction, Dfs, is subtracted from Dtw at a differential. The differential output is Sight Deflection, Ds.

$$Dtw - Dfs = Ds$$

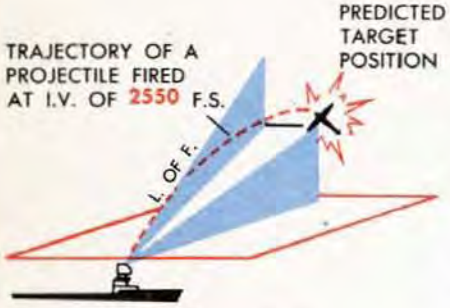
Since a prediction for the effect of Wind is contained in the value of Dtw, Ds also contains this Wind prediction. Projectiles fired using this adjusted value of Ds will be fired at an *imaginary* Predicted Target Position, but the Wind and Drift will affect the trajectory so that the projectiles burst at the *true* Predicted Target Position.



Using the adjusted values of Vs, Ds, and F, accurate values of Gun Train Order, Gun Elevation Order, and Fuze Setting Order can be computed, which will take into account not only Relative Motion, Drift, and Gravity, but also the effect of Wind on the projectile during the Time of Flight.

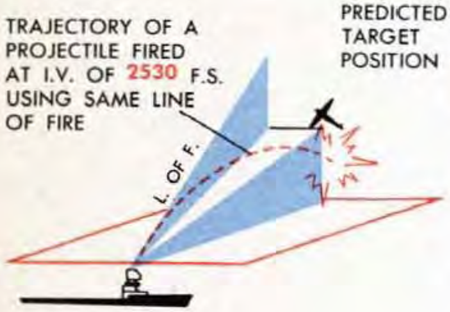
The only remaining corrections to Vs, Ds, and F, necessary to insure accurate predictions, are the corrections to allow for changes in the Initial Velocity of the projectiles.

INITIAL VELOCITY



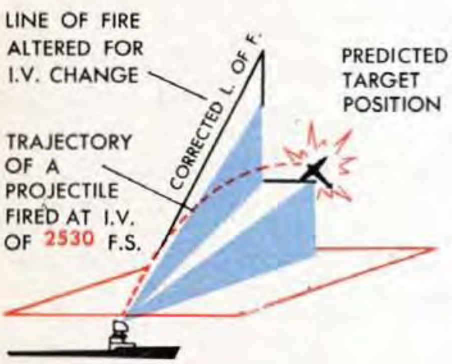
If all projectiles could be fired at an Initial Velocity of 2550 f.s., the computations for *Vs, Ds,* and *F* already described would be accurate.

All projectiles cannot be fired at an Initial Velocity of 2550 f.s. because wear on the gun rifling and changes in temperature and humidity of the powder charges all act to alter the Initial Velocity. An altered Initial Velocity will change the trajectory of a projectile. To offset this change in the trajectory, *Vs, Ds,* and *F* must be corrected. These corrections are called *I.V.* corrections.



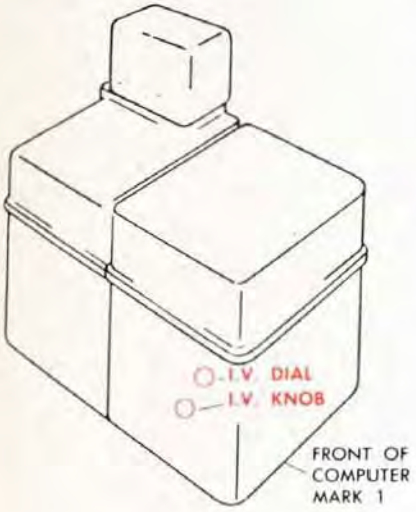
How a change in initial velocity alters a trajectory

A projectile fired at an *I.V.* below 2550 f.s. will travel more slowly and will drop sooner than a projectile fired at or above 2550 f.s. velocity. Without *I.V.* corrections, the projectile fired at a low *I.V.* would burst short of and below the Predicted Target Position. The *I.V.* corrections to *Vs, Ds,* and *F* to compensate for this changed trajectory are, therefore, based on an increased Advance Range, *R2,* an increased Advance Elevation, *E2,* and an increased Superelevation, *Vf.*



Determining the value of initial velocity

Each Computer computes for several guns. The average Initial Velocity of all the guns is determined according to ship's doctrine. This average Initial Projectile Velocity is the value of Initial Velocity, *I.V.,* used at the Computer.



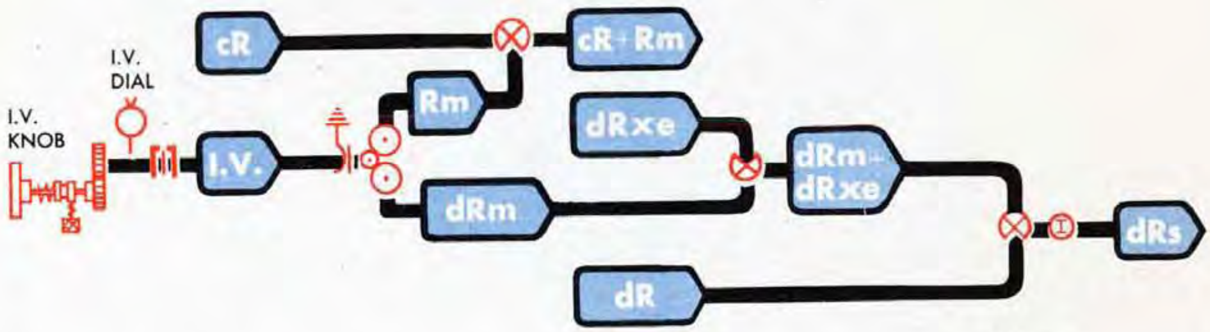
Putting I.V. into the computer

The ordered average Initial Velocity is set into the Computer by turning the *I.V.* Knob. The value of *I.V.* is read on the *I.V.* Dial. When *I.V.* is 2550 f.s., the *I.V.* Dial reads 2550, and the *I.V.* alteration in the Computer is zero. When *I.V.* is more or less than 2550 f.s., the value of the *I.V.* alteration in the Computer is equal to the difference between 2550 f.s. and the *I.V.* Dial reading.

Altering R2 for a change in initial velocity

Two alterations are made in Advance Range, *R2*, for each change in Initial Velocity, *I.V*.

The first alteration, called *Rm*, is obtained by means of a gear ratio on the *I.V*. shaft line. Thus, it will be proportional to the change in Initial Velocity. *Rm* is added to Generated Range, *cR*, at a differential.

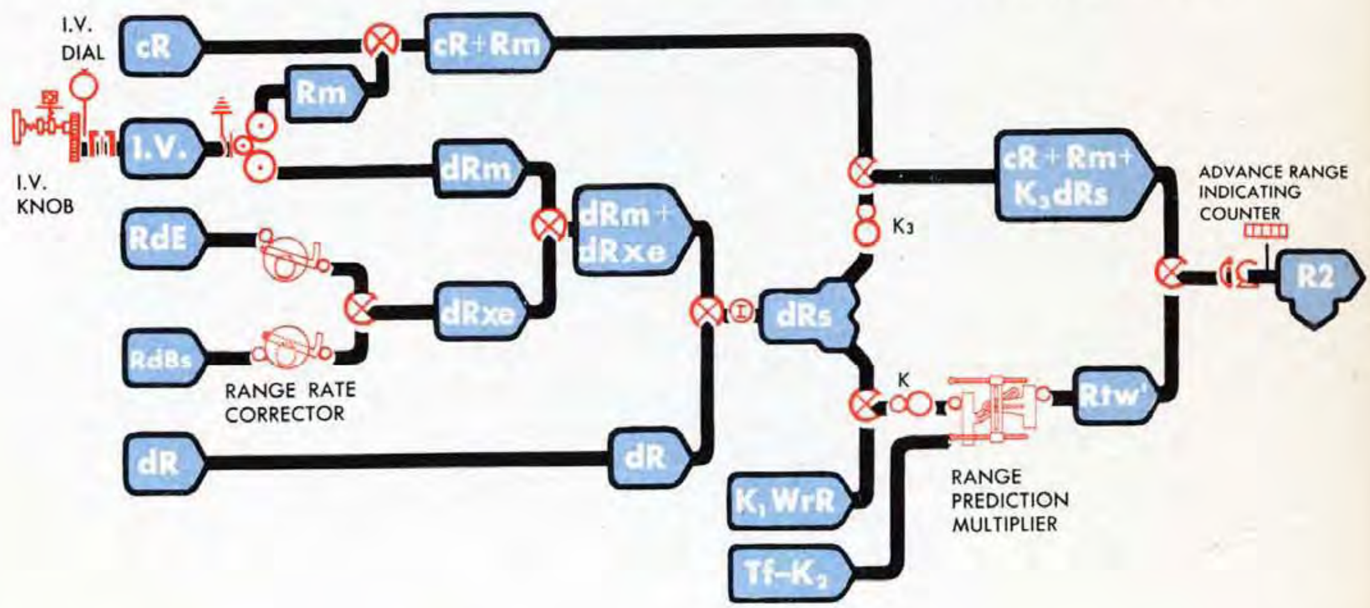


The second *I.V*. alteration is proportional both to the change in *I.V*. and to the value of Time of Flight, *Tf*. This alteration is obtained by multiplying *I.V*. by a constant to produce *dRm*.

In order to multiply *dRm* by *Tf* in the Range Prediction Multiplier, *dRm* is used to alter Prediction Range Rate, *dRs*. The alteration quantity, *dRm*, is added to Range Rate Correction, *dRxe*; then the sum of *dRxe* and *dRm* repositions the *dRs* shaft line. The *I.V*. alteration, ($dRm \times Tf$), does not exist as a separate quantity, but is contained in *Rtw'*, the output of the Range Prediction Multiplier. $dRm \times Tf$ is the *I.V*. alteration of Range Prediction.

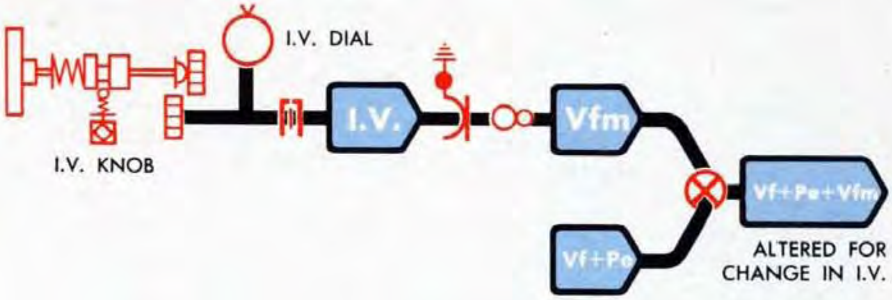
Since Advance Range, *R2*, is the sum of the two quantities *Rtw'* and ($cR + Rm + K_3dRs$), each of which contains an *I.V*. alteration, both *Rm* and ($dRm \times Tf$) are contained in *R2*.

NOTE:
Although the 5"/38 cal. projectiles have a standard or nominal Initial Velocity of 2600 f.s., the ballistic cams and *I.V*. gearing of the Computer were designed for projectiles with an intermediate Initial Velocity of 2550 f.s. One of the reasons why 2550 f.s. was chosen instead of 2600 f.s. was that, from a base of 2550 f.s., *I.V*. corrections can be made in either direction, thus reducing the size of the maximum correction and increasing the accuracy of the average correction.



Correcting Vf for a change in I.V.

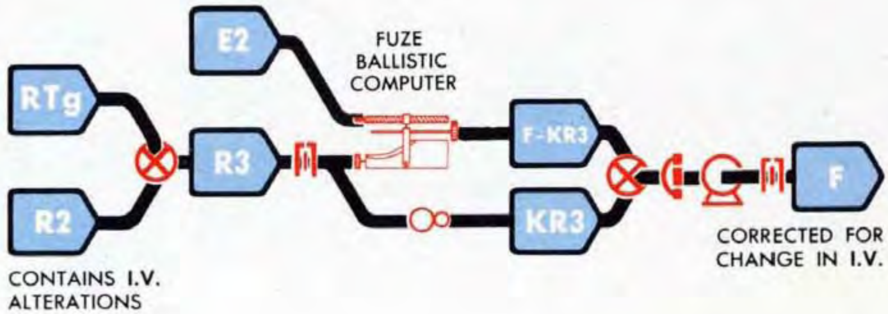
Since a decrease in Initial Velocity causes the projectiles to drop and explode below the Target, the value of Superelevation, *Vf*, must be increased. One part of the *I.V.* correction to *Vf* is called *Vfm*. *Vfm* is computed by multiplying the value on the *I.V.* shaft line by a constant at a gear ratio. *Vfm* is added to the output of the *Vf* + *Pe* Ballistic Computer, forming the quantity *Vf* + *Pe* + *Vfm*, which represents Superelevation containing an *I.V.* alteration, plus Elevation Parallax. The *I.V.* alterations of *R2* and *E2* also play a part in correcting *Vf*, because *R2* and *E2* are the inputs to the *Vf* + *Pe* Ballistic Computer.



How Fuze Setting Order, F, is corrected for a change in I.V.

The value of *R2* used in the Fuze Setting Order network contains an *I.V.* alteration. *R2* is added to the output of the Dead Time Prediction Multiplier to produce *R3*; therefore the *I.V.* alteration in *R2* is also contained in *R3*. *R3* turns the cam in the Fuze Ballistic Computer.

Since *R3* contains this *I.V.* alteration, the value of Fuze Setting Order, *F*, coming from the Fuze Ballistic Computer will be corrected for the deviation in *I.V.* from 2550. This *F* will set the fuze for a burst at the Predicted Target Position in spite of the lower Initial Velocity of the projectile.



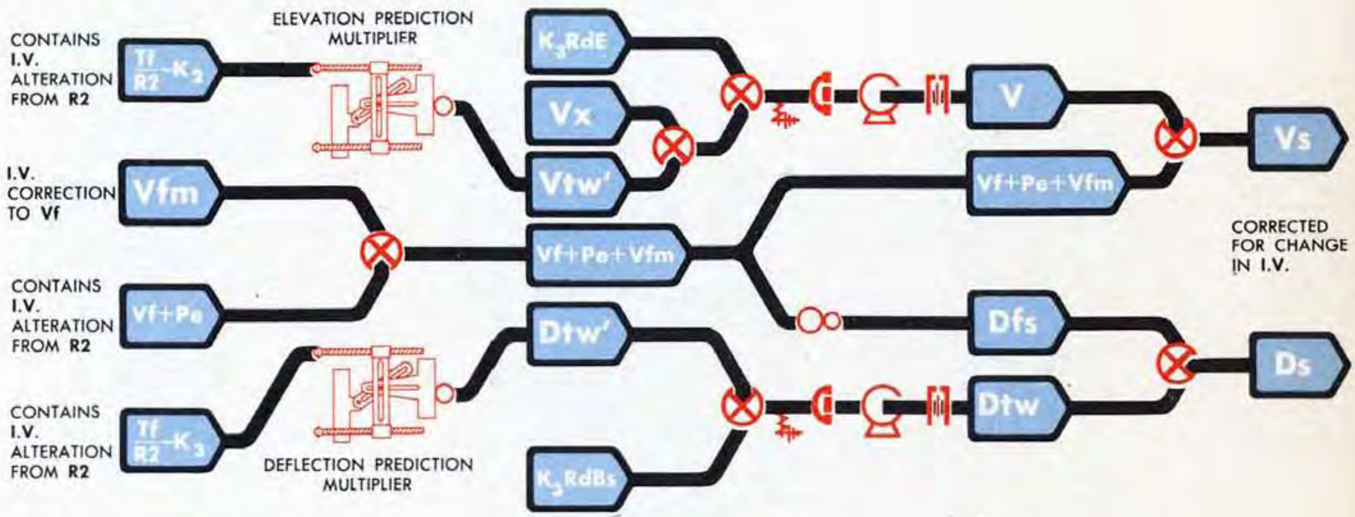
How I.V. alterations to R2 and Vf correct Vs

The value of *R2* containing an *I.V.* alteration positions the cam in the *Tf/R2* Ballistic Computer. The value of *Tf/R2* coming from this computer therefore also contains an *I.V.* alteration. The altered *Tf/R2* causes *I.V.* alterations to be contained in the Elevation Prediction quantities computed using this value of *Tf/R2*. These quantities are *Vtw'*, *V*, and *Vs*.

In addition to the *I.V.* corrections introduced by means of the altered *Tf/R2* line, *Vs* contains *I.V.* corrections introduced through the $Vf + Pe + Vfm$ line.

$Vf + Pe + Vfm$ contains two *I.V.* corrections. One is introduced by use of the altered value of *R2* as an input to the $Vf + Pe$ Ballistic Computer. The other, *Vfm*, supplements the correction introduced by the altered *R2*.

Since the quantity $Vf + Pe + Vfm$ is added to *V* to form *Vs*, all the *I.V.* corrections are introduced into *Vs*. The value of *Vs* includes all the elevation corrections to compensate for the drop of the projectile due to a change in Initial Velocity.



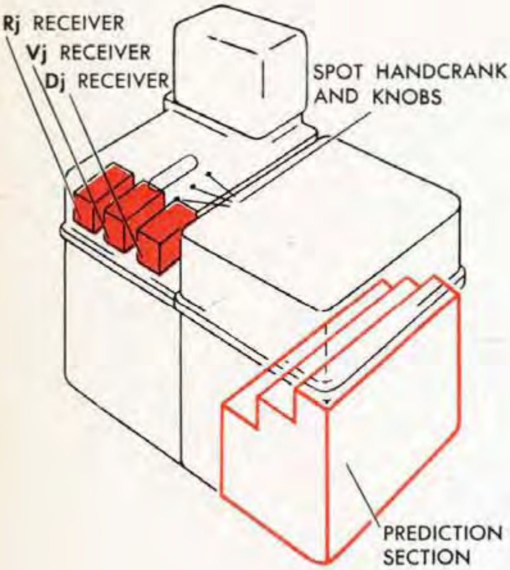
How I.V. alterations to R2 and Vf correct Ds

The *I.V.* alterations in *R2* introduce an *I.V.* alteration into *Tf/R2*. *Tf/R2* is part of the input to the lead screw of the Deflection Prediction Multiplier; therefore the output of this multiplier, *Dtw'*, also contains an *I.V.* correction.

The value of Drift Correction, *Dfs*, is obtained by a gear ratio from the $Vf + Pe + Vfm$ line, which contains *I.V.* corrections. Therefore these corrections are also contained in *Dfs*.

Sight Deflection, *Ds*, consists of the two quantities, *Dtw* and *Dfs*. Each of these contains *I.V.* corrections; therefore *Ds* itself contains *I.V.* corrections. In this way *Ds* is altered to allow for the changes in Deflection required by the changed Initial Velocity.

SPOTS



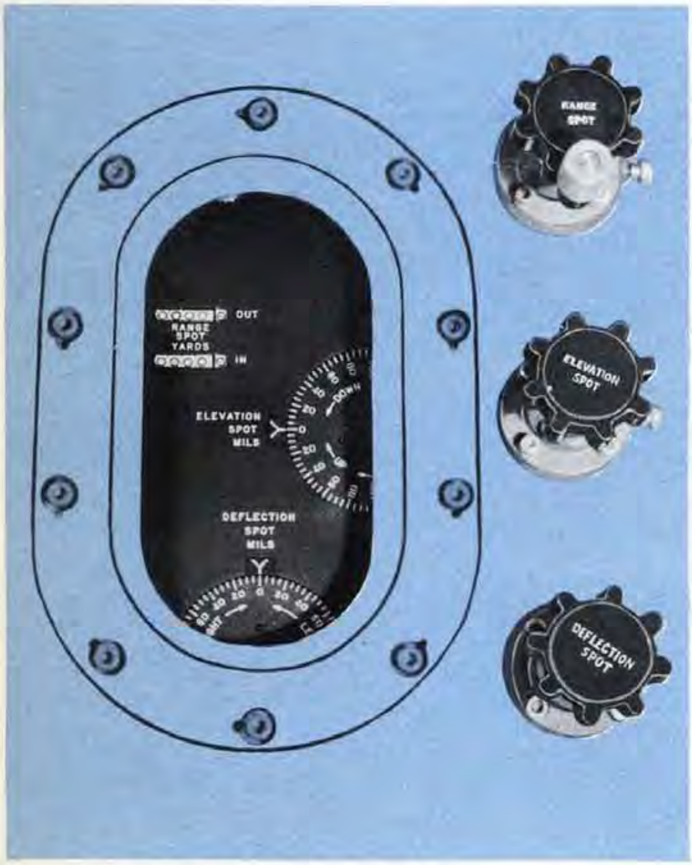
Spots are quantities which may be used to alter the values of the outputs of the Prediction Section. The use of Spots varies with each type of operation and is established by *ship's doctrine.*

There are three Spots used in the Prediction Section:

1. Range Spot, *Rj,* which is a linear alteration of Advance Range, *R2.*
2. Elevation Spot, *Vj,* which is an angular alteration of Sight Angle, *Vs.*
3. Deflection Spot, *Dj,* which is an angular alteration of Sight Deflection, *Ds.*

Each of these Spots may be put into the Prediction Section either by synchro transmission from the Director or by hand at the Computer.

The spot mechanisms



SPOT COUNTERS, DIALS, HANDCRANK AND KNOBS

Each Spot may be transmitted automatically from the Director to a single-speed receiver in the Computer. The Range Spot may be received at the *Rj* Receiver, the Elevation Spot at the *Vj* Receiver, and the Deflection Spot at the *Dj* Receiver. All three Spot Receivers are single-speed receivers.

The *Rj* Handcrank and the *Vj* and *Dj* Knobs each have two positions, IN and OUT. When the handcrank and knobs are in their OUT positions, they are disconnected from the *Rj*, *Vj*, and *Dj* lines. The electrical circuits to the *Rj*, *Vj*, and *Dj* Receivers are completed and the lines are positioned by the Spot receivers.

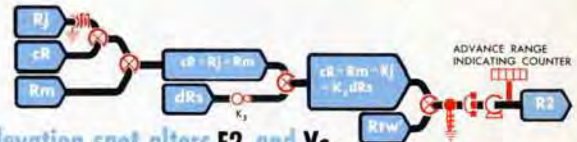
When the handcrank and knobs are in their IN positions, the circuits to the Spot receivers are broken, and the lines are positioned by the handcrank and knobs.

The total value of the Range Spots shows on the Range Spot Counter. The total values of the Elevation and Deflection Spots show on the Elevation and Deflection Spot Dials.

The Spot handcrank, knobs, dials, and receivers are in the rear top section of the Computer Mark 1. Shaft lines from the handcranks and receivers carry the Spot values to the Prediction Section at the front of the Computer.

How the range spot alters R2

Range Spot, Rj, is added to Generated Present Range, cR, at a differential. The output of this differential is used in computing Advance Range, $R2$; therefore $R2$ may be increased or decreased by use of the Range Spot, Rj.



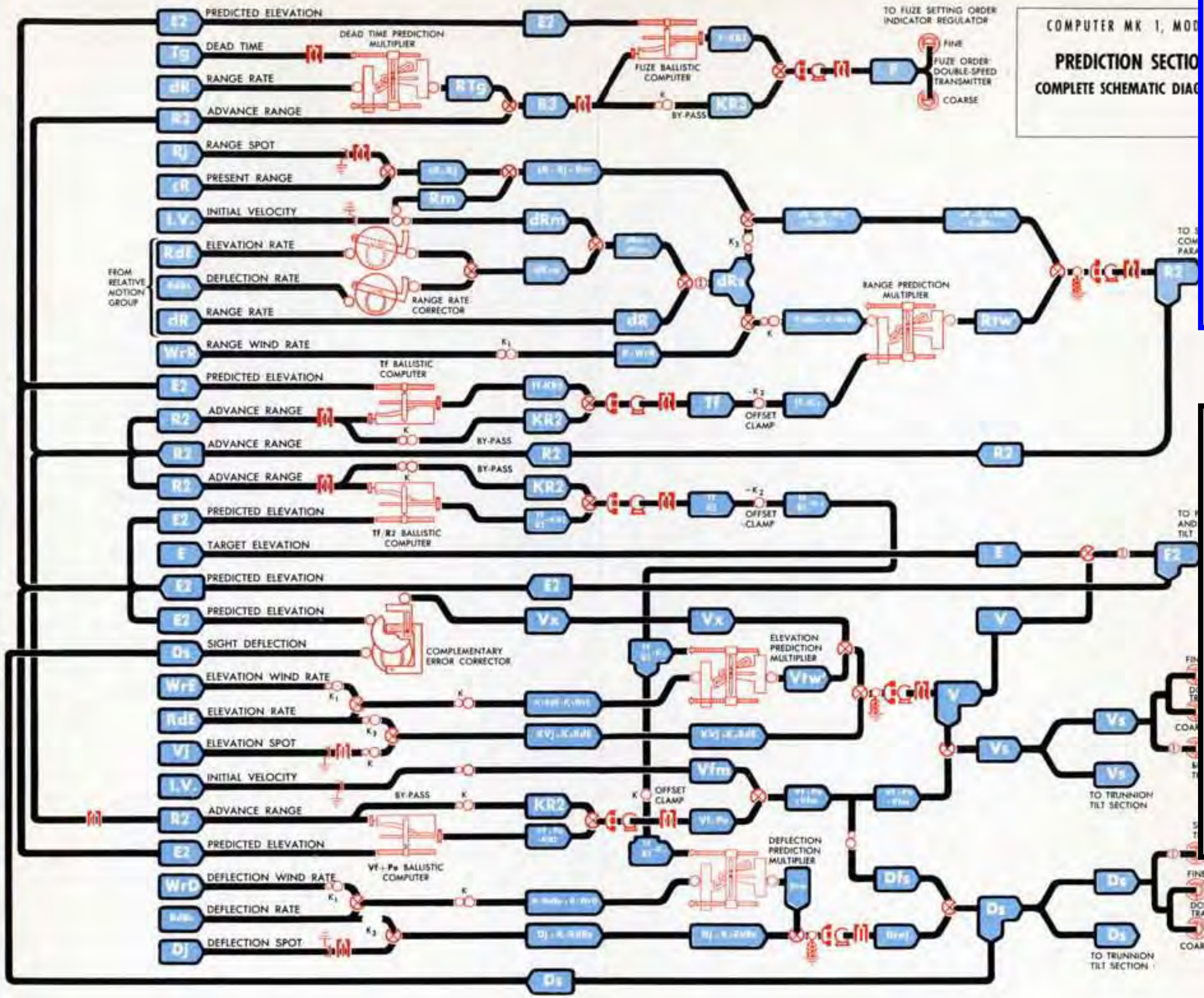
How the elevation spot alters E2 and Vs

Elevation Spot, Vj, is added to K_1RdE and becomes part of the by-pass of the Elevation Prediction Multiplier. The by-pass quantity is used in computing V; therefore, V is offset by the amount of the Elevation Spot, Vj. Since the value of V containing the Spot is used in computing Vs and $E2$, the values of these quantities are also offset by Vj.

Any change in $E2$ caused by Elevation Spot, Vj, affects the outputs of the four ballistic computers. The effect of this change will be small, however, since the maximum Elevation Spot that can be introduced through the Vj line is 180 mils, and Elevation changes have less effect on the outputs of the ballistic units than changes in Advance Range.

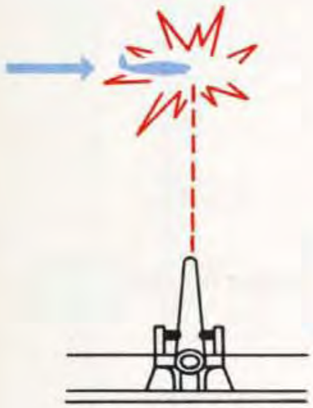
How the deflection spot alters Ds

Deflection Spot, Dj, is added to K_1RdBs and becomes part of the by-pass of the Deflection Prediction Multiplier. $Dj + K_1RdBs$ is added to the multiplier output, Dtw', to form $Dtwj$. Drift Correction, Dfs, is added to $Dtwj$ to form Ds. Ds is therefore offset by the amount of the Deflection Spot, Dj.

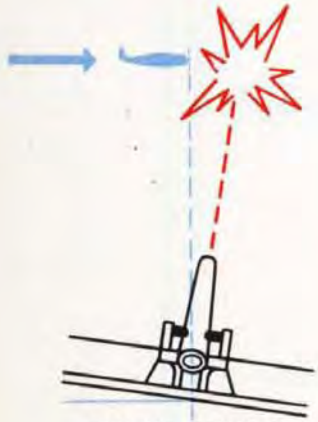


COMPUTER MK 1, MOD
PREDICTION SECTIO
COMPLETE SCHEMATIC DIAG

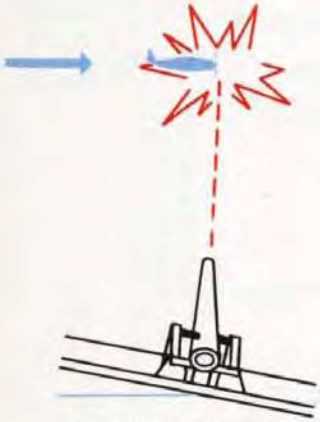
TRUNNION TILT



GUN AIM ESTABLISHED ON HORIZONTAL DECK



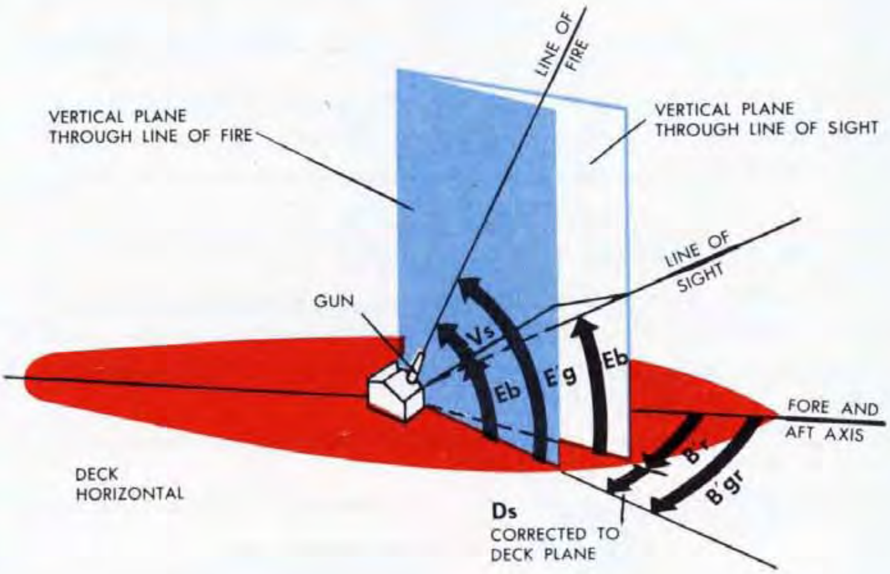
GUN AIM IS FALSE ON TILTED DECK WITHOUT TRUNNION TILT CORRECTIONS



TRUNNION TILT CORRECTIONS CORRECT GUN AIM FOR TILTED DECK

The guns are mounted between trunnions which tilt as the deck rolls and pitches. Trunnion Tilt Corrections are corrections to keep the guns pointing along the Line of Fire despite the tilting of the trunnions.

Since the trunnions are mounted parallel to the deck, the guns must train in the deck plane and elevate in a plane at right angles to the deck. The error in the gun aim caused by tilting of the trunnions must be corrected by continuously altering the Gun Elevation and Train Orders.

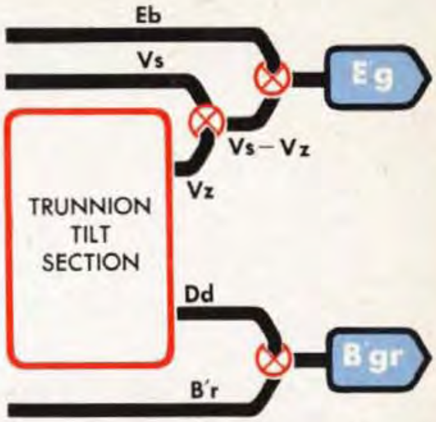


On a horizontal deck the Gun Elevation Order, *E′g*, consists of Director Elevation, *Eb*, plus Sight Angle, *Vs*.

On a horizontal deck the Gun Train Order, *B′gr*, consists of Director Train, *B′r*, plus Sight Deflection, *Ds*, converted to the deck plane. (*Ds* is measured in a slant plane. It must be converted to the deck plane before being used in the Gun Train Order.)

The Line of Fire established in this way from the horizontal deck is the line along which the gun must point to hit the Target. If the deck tilts, *the gun must be kept pointed along this Line of Fire, even though the Line will have a different elevation above the deck and a different train angle from the fore and aft axis of Own Ship.*

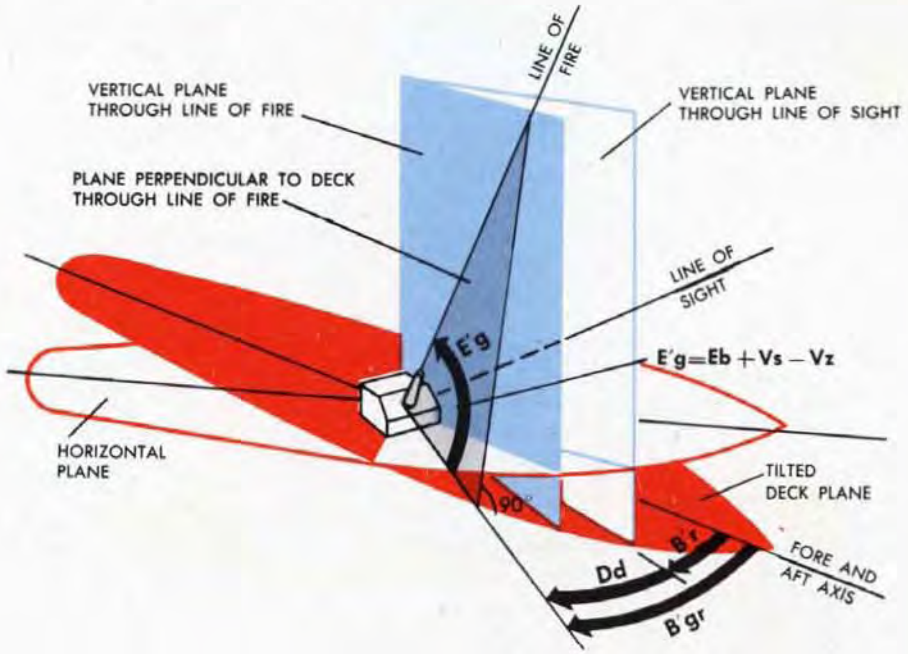
The Trunnion Tilt Section of the Computer Mark 1 computes two quantities. The first is Trunnion Tilt Elevation Correction, *Vz*, the second is Deck Deflection, *Dd*, which includes Trunnion Tilt Train Corrections.



Trunnion Tilt Elevation Correction, *Vz*, is continuously subtracted from *Eb* + *Vs* to obtain Gun Elevation Order, *E'g*, measured from a tilting deck.

$$E'g = Eb + Vs - Vz$$

Deck Deflection, *Dd*, is the sum of Partial Deck Deflection, *jDd*, and Trunnion Tilt Train Correction, *Dz*.



The partial correction, *jDd*, represents *Ds* converted to the deck plane. *Dz* is approximately the Trunnion Tilt Train Correction to compensate for Cross-level, *Zd*.

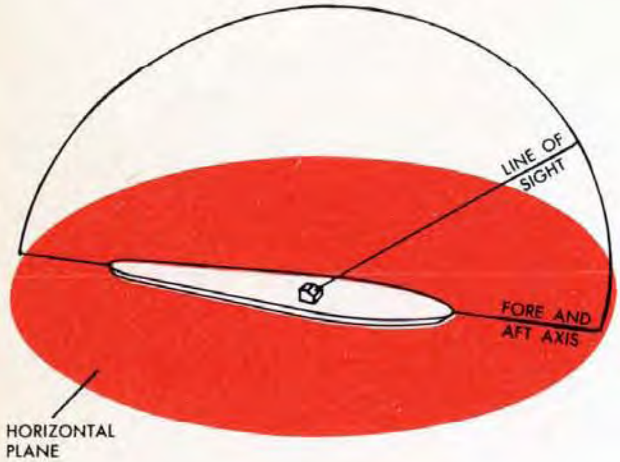
$$Dd = jDd + Dz$$

Deck Deflection, *Dd*, is continuously added to Director Train *B'r*, to obtain Gun Train Order, *B'gr*, measured in a tilting deck plane.

$$B'gr = B'r + Dd$$

The corrected Gun Train Order, *B'gr*, locates the base of a plane *at right angles to the deck* in which the gun can be elevated to lie on the Line of Fire. In this plane at right angles to the deck, the corrected Gun Elevation Order, *E'g*, continuously establishes the elevation of the Line of Fire above the tilting deck.

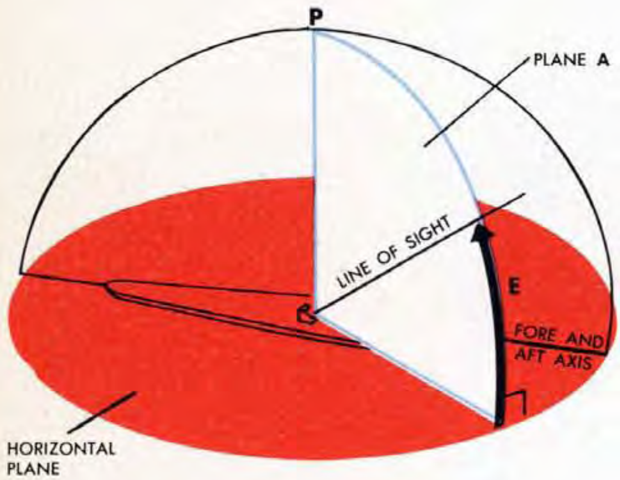
SETTING UP THE LINE OF FIRE FROM THE HORIZONTAL



To illustrate the Trunnion Tilt Corrections in detail a series of spherical diagrams will be used. The Director of Own Ship is considered to be at the center of the sphere or ball.

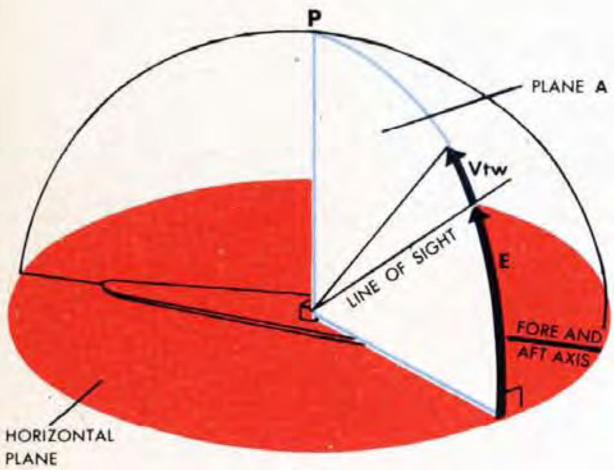
In these spherical diagrams any angle that has its vertex at the center of the sphere can be measured by the arc it cuts off on the surface of the sphere. (The vertex of an angle is the point where the two sides of the angle intersect.)

These diagrams show, first, how the Line of Fire is established on a horizontal deck and, second, how the Trunnion Tilt Corrections keep the gun pointing along the Line of Fire as the deck tilts.



A horizontal plane passes through the center of the sphere at the level of the Director of Own Ship. The Line of Sight runs from the center of the sphere to the Target

A line at right angles to the horizontal plane runs from the center of the sphere to point P at the top of the sphere. A vertical plane passes through this line and through the Line of Sight. This plane is called plane A, or the vertical plane through the Line of Sight.

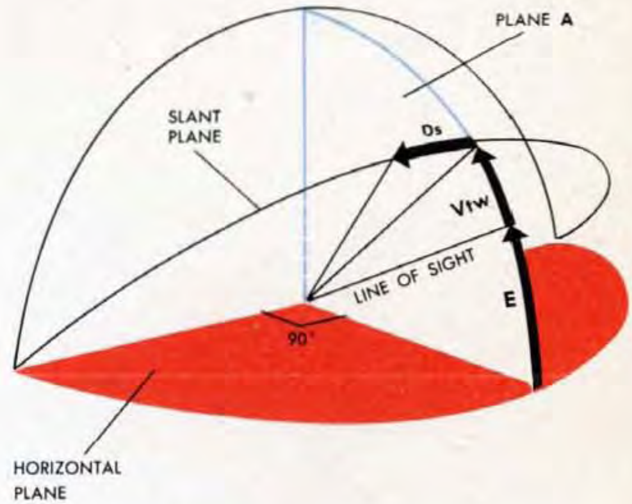


Target Elevation, *E*, is the elevation of the Line of Sight above the horizontal in this vertical plane.

Angle *Vtw*, the Partial Elevation Prediction, is now added to *E* in the vertical plane through the Line of Sight. Both *E* and *Vtw* are measured by the arcs they cut off on the surface of the sphere.

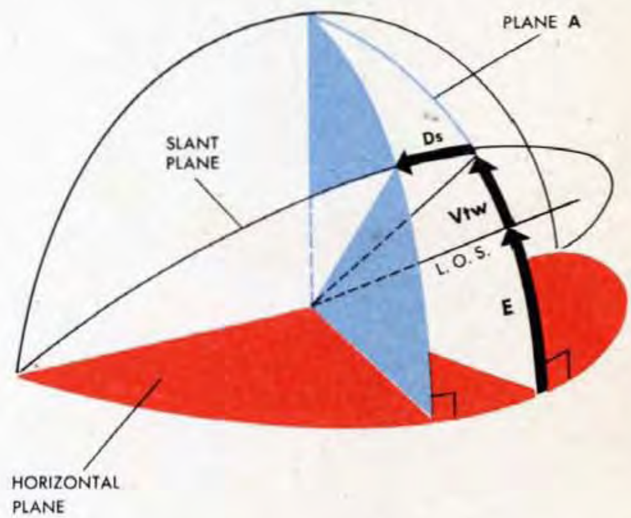
A slant plane is now added at right angles to plane A and at angle $E + Vtw$ to the horizontal plane.

Sight Deflection, *Ds,* is measured in this slant plane. One side of *Ds* lies in the vertical plane containing the Line of Sight.



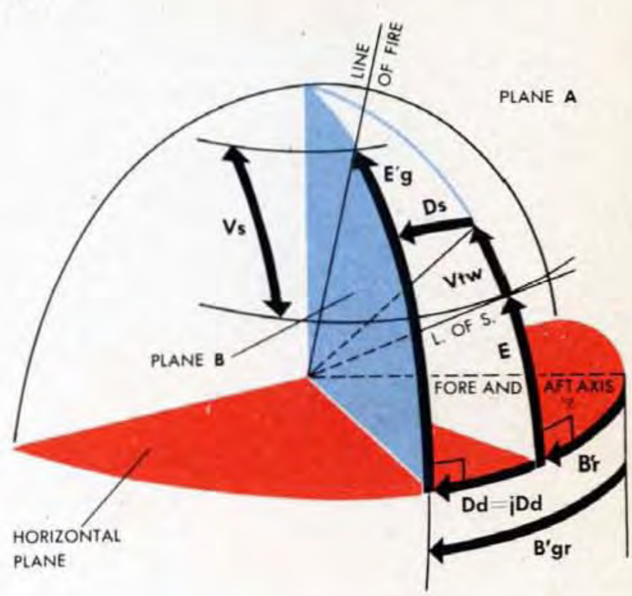
Another vertical plane, plane B, passes through the other side of angle *Ds.* This new vertical plane is the plane containing the Line of Fire.

The Line of Fire is now obtained by transferring angle *E* from plane A to plane B and adding *Vs* to angle *E* in this plane. Only the part of the slant plane actually contained in angle *Ds* is shown here.



Measuring the Line of Fire from the horizontal deck, the Gun Elevation Order, *E′g,* consists of *E* plus *Vs,* since *E* equals *Eb* when the deck is horizontal.

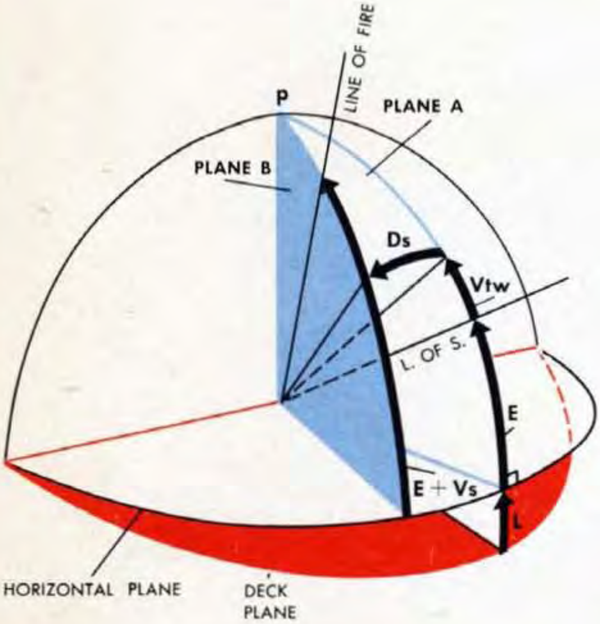
Gun Train Order, *B′gr,* is *B′r* plus *Dd.* Since the deck is horizontal, *Dd* consists only of *Ds* corrected to the deck plane. *Dz* is zero, since there is no Cross-level. *Dd,* therefore, equals *jDd.*



The Line of Fire shown in this picture must be maintained whether or not the deck is horizontal. The Trunnion Tilt Corrections alter the gun angles to keep the gun on the Line of Fire regardless of how the deck tilts.

THE LINE OF FIRE FROM A TILTED DECK

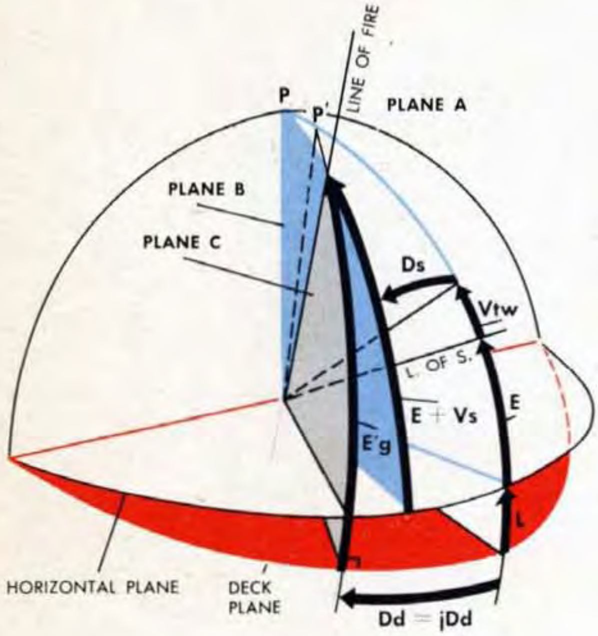
With level only



Now the deck is tilted down in Level.

Level, *L*, is the angle between the deck plane and the horizontal plane, measured in a vertical plane through the Line of Sight.

The Line of Fire as shown here has been established from the horizontal plane. Since the gun can only be elevated in a plane at right angles to the deck, a new plane must be found which passes through the Line of Fire, *and is at right angles to the deck.*



Plane C is this new plane. Since the deck is tilted, the line at right angles to the deck now passes through point P′. Plane C passes through this line, and through the Line of Fire. The train angle between plane A containing the Line of Sight and plane C containing the Line of Fire is Deck Deflection, *Dd*. *Dd* still consists of *jDd* only. *Dz* is zero since Cross-level, *Zd*, is zero.

The elevation of the Line of Fire above the deck in plane C is Gun Elevation Order, *E′g*, which now consists of *Eb* + *Vs*. The value of *Vz* is zero.

With level and cross-level

Cross-level, *Zd*, is the angle of roll of the deck about a line which is the intersection of the deck plane with the vertical plane through the Line of Sight.

When the deck is tilted in both Level and Cross-level, the line perpendicular to the deck passes through point P″.

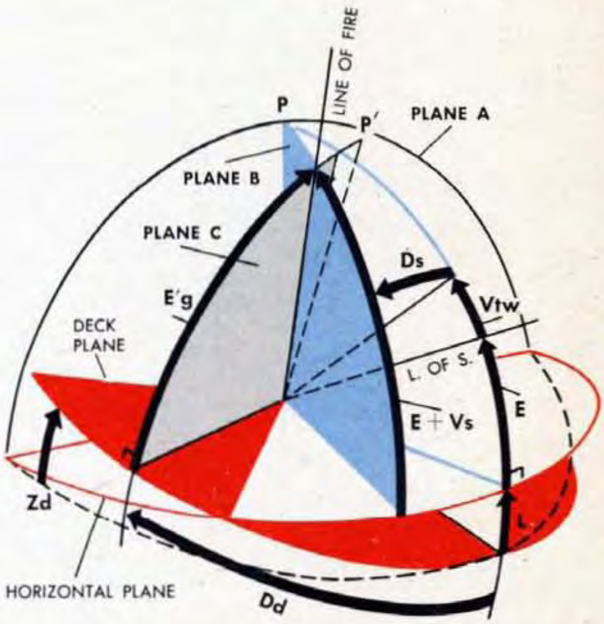
Plane C containing the Line of Fire now makes a different angle with plane A. *Dd* has changed by an amount, *Dz*, the Trunnion Tilt Train Correction to compensate for Cross-level.

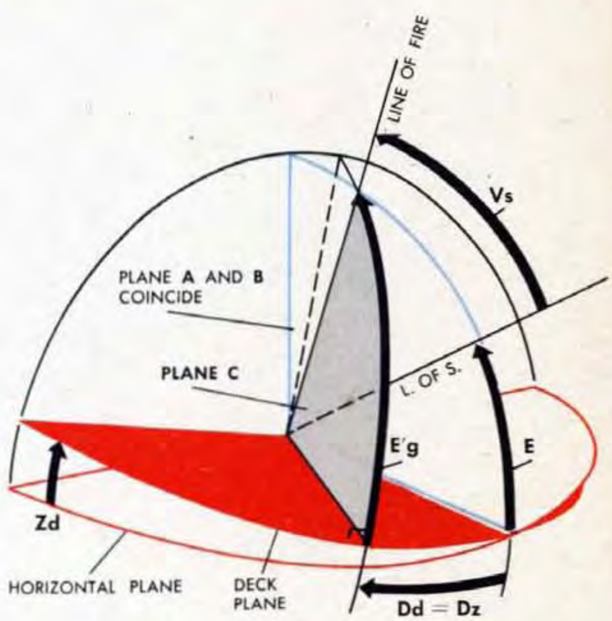
It is difficult to show *jDd* and *Dz* separately in a diagram when both are present. A simple way to illustrate *Dz* is to show a case in which *jDd* is zero and where *Dd* consists only of *Dz*.

jDd is zero when *Ds* is at its zero position, that is, when the *Ds* Counter reads 500 mils. Then the Line of Fire lies in the vertical plane through the Line of Sight.

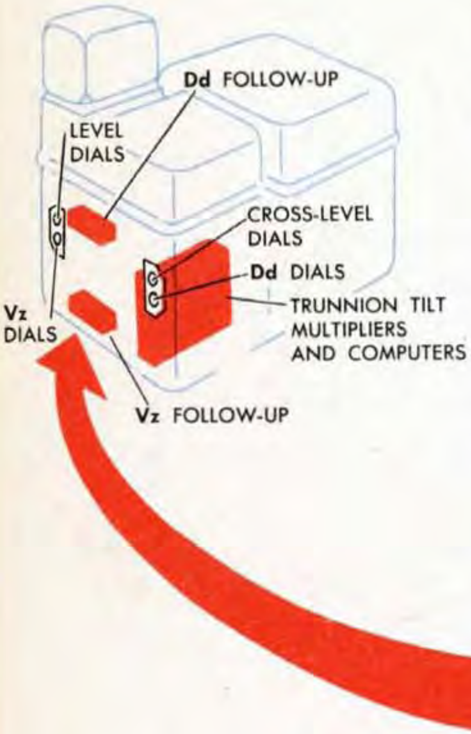
Here is such a case. Both *Ds* and *L* are zero. The deck is tilted in Cross-level only. Plane C, at right angles to the deck and passing through the Line of Fire, is at train angle *Dz* to plane A.

Here *Dd* = *Dz*.





The mechanisms and the equations



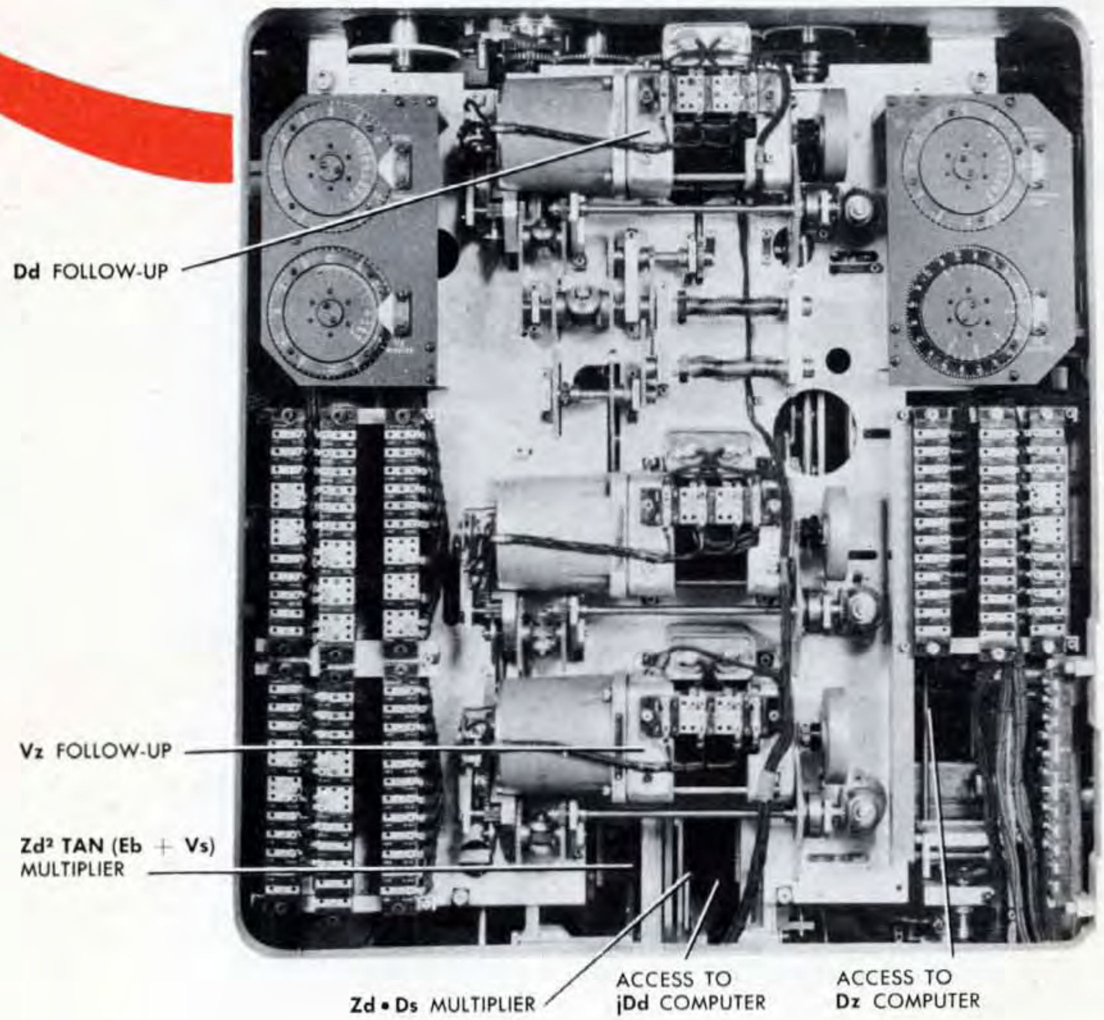
The Trunnion Tilt Section contains four computing mechanisms: a rack-type multiplier, a double-cam computing multiplier, and two special computers. This section also contains the *Vz* and *Dd* Follow-ups and Dials, the *L* and *Zd* Dials, various differentials, and a spring relief drive.

These mechanisms are all located at the back of the Computer Mark 1 and are used to solve the equations for *Vz* and *Dd*.

The true equations for both *Vz* and *Dd* are complex and cannot be solved mechanically without using many cumbersome mechanisms.

Because of this, the true equations have been modified in many ways. The modified equations can be solved with only a few mechanisms, and provide a solution within the required limits of accuracy.

Since the equations are modifications there is no point in deriving them here. They are just equations which give values of *Vz* and *Dd* close enough to the true values to keep the errors very small under most operating conditions.



COMPUTING Vz

Vz is the Trunnion Tilt Elevation Correction.

The *Vz* equation has two terms: one is $K \cdot Zd^2 \tan(Eb + Vs)$. The other term is $K_1\ Zd \cdot Ds$. Each of these terms is computed in a multiplier; then the two terms are added together in a differential.

The whole equation is:

$$Vz = K \cdot Zd^2 \tan(Eb + Vs) + K_1\ Zd \cdot Ds.$$

The *K* terms are constants introduced by gearing.

The Zd² tan (Eb + Vs) Multiplier

$Zd^2 \tan(Eb + Vs)$ is computed in a double-cam computing multiplier. The cams in this multiplier are a square cam and a tangent cam.

Cross-level, *Zd,* from the Stable Element goes to the square cam in this multiplier, which puts values of Zd^2 into the multiplier mechanism. (Zd^2 is also driven out to be used in computing *jDd.*)

Director Elevation, *Eb,* is added to Sight Angle, *Vs,* in differential D-13. Their sum, $Eb + Vs$, positions the tangent cam, putting $\tan(Eb + Vs)$ into the multiplier mechanism.

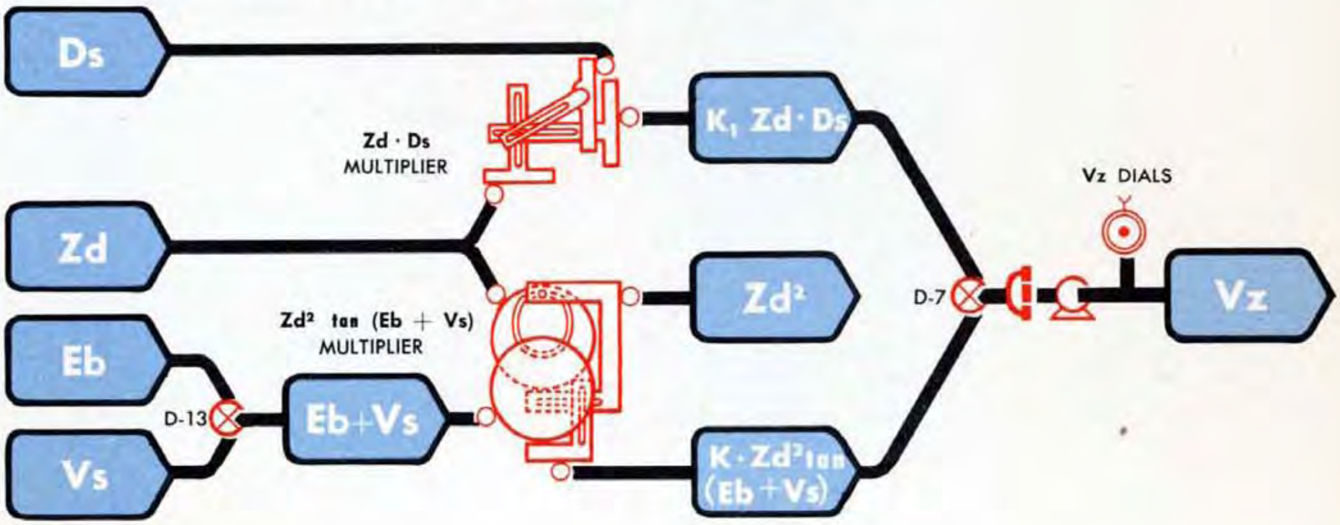
The multiplier output is $K \cdot Zd^2 \tan(Eb + Vs)$, the first term of the *Vz* equation.

The Zd · Ds Multiplier

$K_1\ Zd \cdot Ds$ is computed in a rack-type multiplier.

Cross-level, *Zd,* goes to the input rack. Sight Deflection, *Ds,* positions the input pivot arm. The output is $K_1\ Zd \cdot Ds$, the second term of the *Vz* equation.

The outputs of these two multipliers are added in differential D-7. The differential output is *Vz,* the Trunnion Tilt Elevation Correction. *Vz* is amplified by a compensated follow-up. Its value can be read on dials at the back of the Computer.



COMPUTING Dd

Deck Deflection, *Dd,* consists of Sight Deflection, *Ds,* corrected to the deck plane, and the train corrections for Trunnion Tilt.

The equation for *Dd* consists of the two terms, *jDd* and *Dz.*

$$Dd = Dz + jDd$$

Dz is approximately the Trunnion Tilt Train Correction for Cross-level.

jDd is approximately Sight Deflection, *Ds,* corrected to the deck plane.

The values of *jDd* and *Dz* are each computed in a special computer.

The Dz Computer

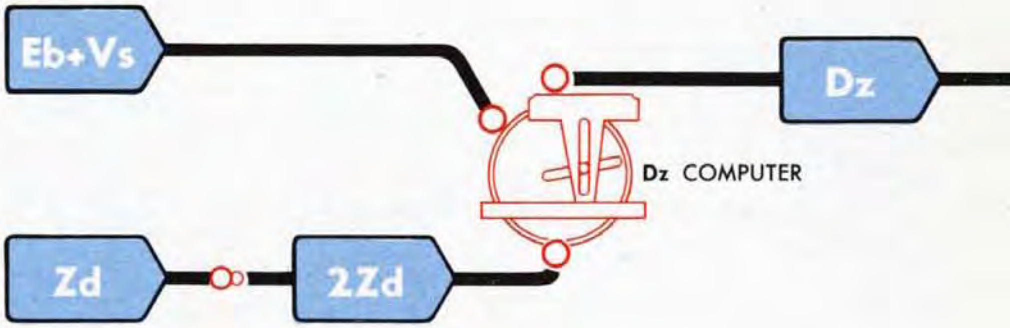
The *Dz* Computer is a component solver with only one rack.

This Computer solves the equation $f(Eb + Vs) \sin 2Zd$, which gives a close approximation of the true value of *Dz.*

$Eb + Vs$, which was one of the inputs to the $Zd^2 \tan(Eb + Vs)$ Multiplier, also positions the computing cam in the *Dz* Computer, putting in $f(Eb + Vs)$.

Cross-level, *Zd,* becomes *2Zd* through gearing, and the value of *2Zd* positions the vector gear.

The output is $f(Eb + Vs) \sin 2Zd$, which is called *Dz.*



The jDd Computer

The quantity $\sin^{-1}[Ds \cdot \sec(E2 + L - K \cdot Zd^2)]$ is used to give a good approximation of the real value of *jDd*.

Sin^{-1} means "the angle whose sine is;" therefore angle *jDd* is the angle whose sine is $Ds \cdot \sec(E2 + L - K \cdot Zd^2)$.

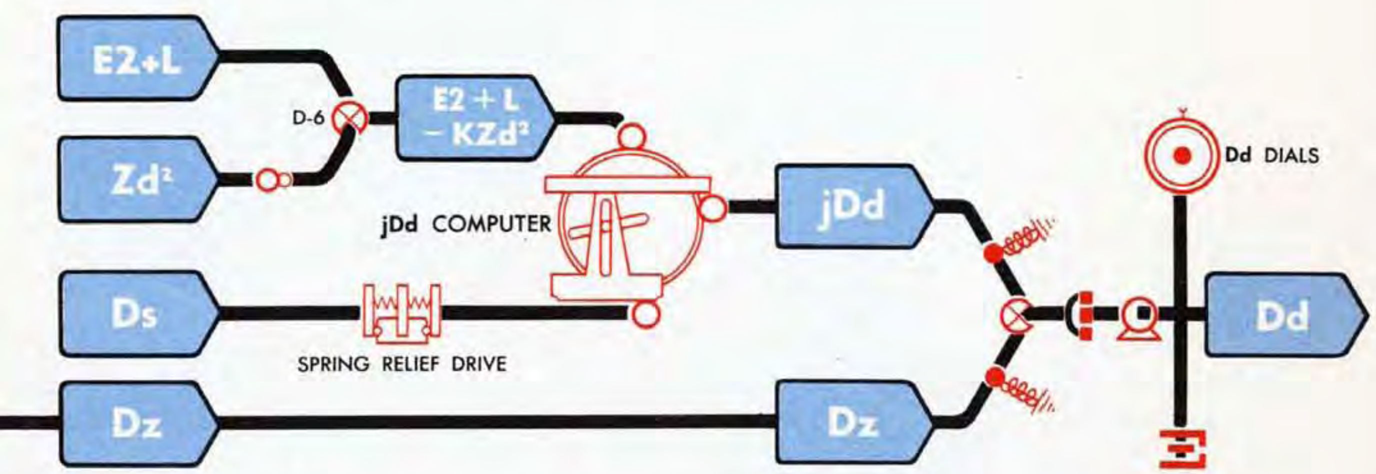
Since the secant is the reciprocal of the cosine, the equation for *jDd* can also be written in this form:

$$jDd = \sin^{-1}\left(\frac{Ds}{\cos(E2 + L - K \cdot Zd^2)}\right)$$

This equation is solved in the *jDd* Computer, which is similar to a component solver with only one rack.

A component solver used in the ordinary way has outputs equal to the cam input multiplied by the sine and cosine of the vector gear input angle.

In the *jDd* equation the value needed is THE ANGLE WHOSE SINE IS $Ds/\cos(E2 + L - K \cdot Zd^2)$. The output, therefore, comes from the vector gear instead of from the rack. The inputs position the cam and the rack.



The value of Zd^2 obtained from the square cam of the $Zd^2 \tan(Eb + Vs)$ Multiplier is multiplied by K in a gear ratio and subtracted from $(E2 + L)$ in differential D-6, giving $(E2 + L - K \cdot Zd^2)$. This value positions the cosine cam of the *jDd* Computer, which gives $\cos(E2 + L - K \cdot Zd^2)$.

Sight Deflection, *Ds*, from the Prediction Section positions the rack of this Computer.

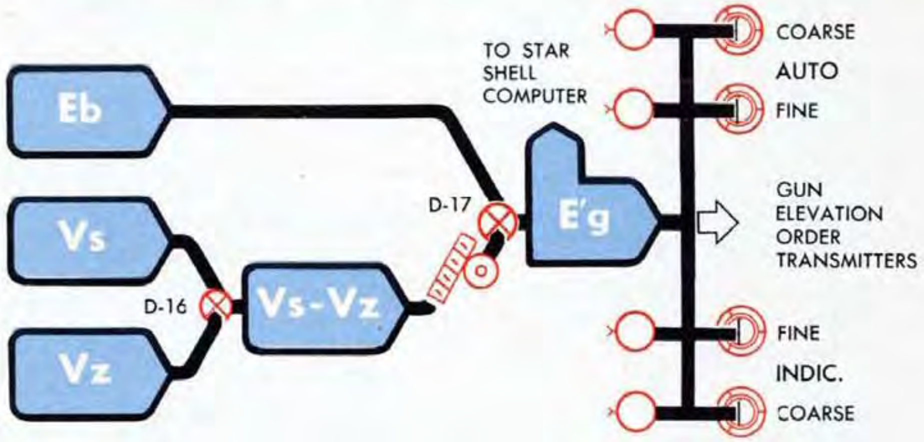
The output from the vector gear is $\sin^{-1}\dfrac{Ds}{\cos(E2 + L - K \cdot Zd^2)}$ or $\sin^{-1}[Ds \cdot \sec(E2 + L - K \cdot Zd^2)]$ which is *jDd*.

The value of *Dz* from the *Dz* Computer is added to *jDd* in differential D-8. The output of this differential is Deck Deflection, *Dd*. *Dd* is amplified by a compensated follow-up, and can be read on dials at the rear of the Computer.

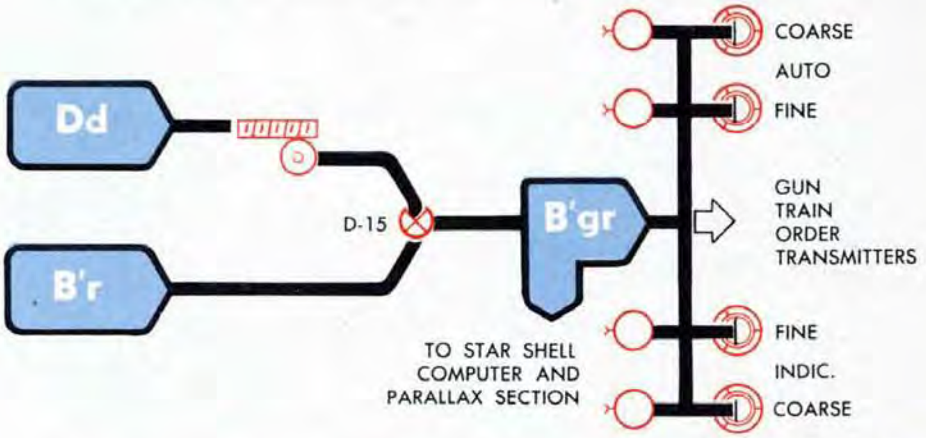
The gun orders

The Gun Elevation Order, $E'g$, is computed by subtracting Trunnion Tilt Elevation Correction, Vz, from Sight Angle, Vs, in differential D-16, and then adding the output $Vs - Vz$ to Director Elevation, Eb, in differential D-17. The output from D-17 is $Eb + Vs - Vz$, which is Gun Elevation Order, $E'g$.

$E'g$ positions two double-speed transmitters. The $E'g$ Transmitters are used to operate indicators at the guns and the automatic gun control equipment. The value of $E'g$ may be read on the transmitter dials.



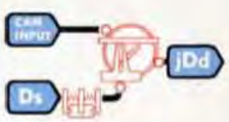
The Gun Train Order, $B'gr$, is computed by adding Deck Deflection, Dd, to Director Train, $B'r$, at differential D-15. The output from the differential is $B'gr$. $B'gr$ positions two double-speed transmitters, which operate indicators at the guns and the automatic gun control equipment. The value of $B'gr$ may be read on the transmitter dials.



To prevent $B'r$ and Eb from backing into the Dd and $Vs - Vz$ lines, respectively, irreversible worms are provided on these lines as mechanical safeguards. This insures that correct values of the Gun Orders will reach the transmitters.

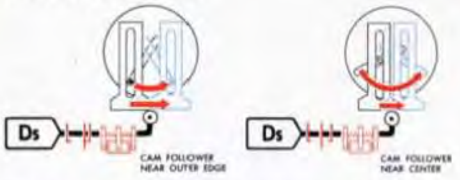
In addition to being used at the guns, $B'gr$ may be used in the Parallax Section of the Computer Mark 1, and both $E'g$ and $B'gr$ are used in the Star Shell Computer Mark 1.

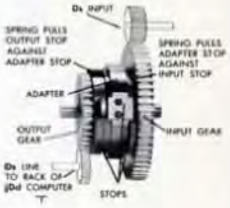
The spring relief drive



A spring relief drive is placed on the *Ds* input line going to the rack of the *jDd* Computer.

The spring relief drive is needed because the limits of travel of the *jDd* Computer rack become less than the limits of *Ds* when the cam follower pin is near the center. This occurs at high values of $E2 + L - K \cdot Zd'$.



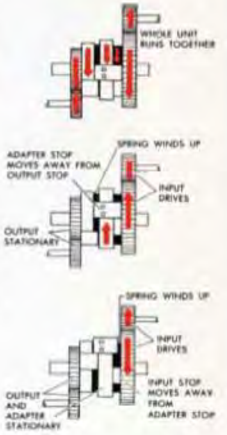


When the cam follower pin is at the outer edge of the cam, rack travel is limited only by the *Ds* limit stop. However, when the follower pin is near the center of the cam, rack travel is reduced, being controlled by the angular limits of the vector gear.

The relief drive mechanism uses two gears and an adapter, each having a stop piece attached. The gear stops are held by two strong clock springs against the sides of the stop on the adapter.

The whole relief drive turns together when the *Ds* line to the rack is free to move.

When travel of the *Ds* rack is limited by the vector gear, the output gear of the relief drive cannot turn. A further change in *Ds* will turn the input gear to the relief drive. Depending on the direction of rotation, one spring or the other will wind, thereby absorbing the additional change of *Ds*.

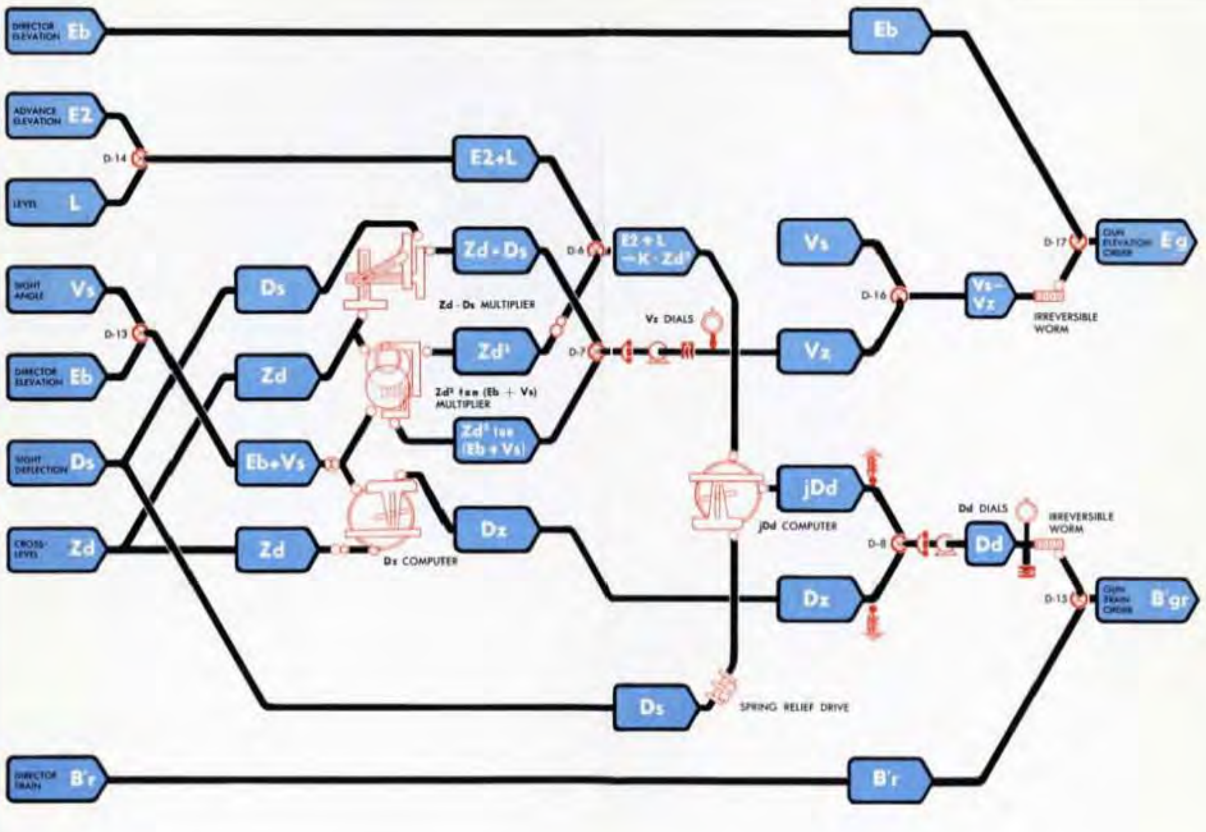


If the *Ds* line continues to drive after the rack has reached one limit of travel, the input gear stop will rotate the adapter. Since the output gear is held, rotation of the adapter will be absorbed by the output gear spring. If the *Ds* line turns in the other direction beyond the limit of rack travel, the input gear spring will absorb the excess input.

When the cam input changes so as allow sufficient travel of the rack, the springs restore the output gear to its original position relative to the input gear. Then the spring relief drive again acts as a solid connection.

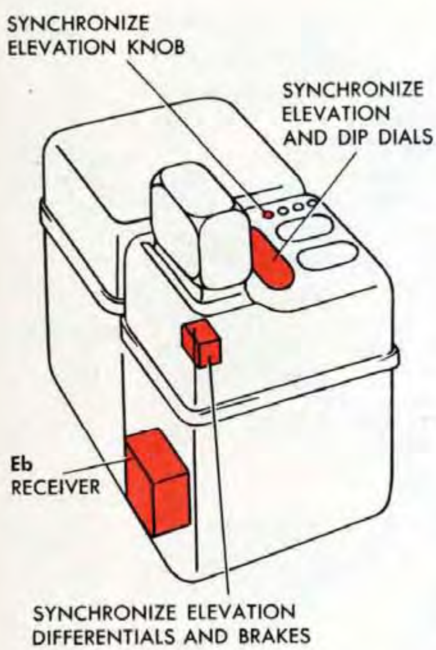
NOTE:
The chapter on *Limits of Accurate Computation* describes the effect on the Gun Orders of the failure of *Ds* to drive into the *jDd* Computer at high values of $E2 + L - K \cdot Zd'$.

COMPUTER MK 1, MOD
TRUNNION TILT SECT
SCHEMATIC DIAGRAM



The SYNCHRONIZE ELEVATION GROUP

The Synchronize Elevation Group consists of the *Eb* Receiver, the *E* Differential, and the Synchronize Elevation Mechanism.



The units of the Synchronize Elevation Group are located in the rear of the Computer. The *Eb* Receiver, the *E* Differential, and all the elements of the Synchronize Elevation Mechanism except the dials and knob are located in the lower rear. The Synchronize Elevation Dials, the Dip Dials, and the Synch *E* Knob are on the top rear.

The *E* Differential is used in Continuous Aim to provide a continuous correct value of Target Elevation, *E*.

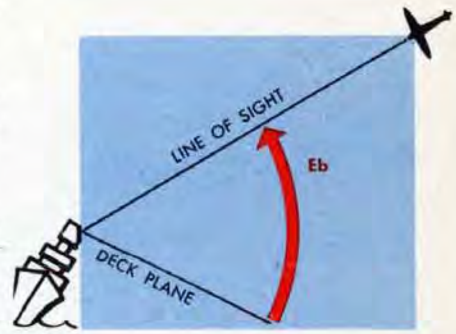
The Synchronize Elevation Mechanism is used to provide for methods of fire which can be used against surface targets but which are not usually practical against air targets. This mechanism can be thought of as a device which takes advantage of the additional fire control methods offered by surface targets.

These other methods are described in this chapter in sufficient detail to show the functions of the Synchronize Elevation Mechanism.

In showing how the Synchronize Elevation Group is used, the *E* Differential is introduced first, and then elements of the Synchronize Elevation Mechanism are added to it as the need for each is briefly explained.

The E Differential

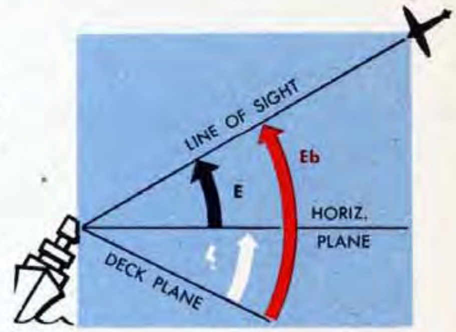
For Continuous Aim the Computer must make continuous accurate computations of gun and fuze orders. To compute these it needs continuous correct values of Director Elevation, *Eb*, for use in the Trunnion Tilt Section and Gun Elevation Order, and continuous correct values of Target Elevation, *E*, for use in the Relative Motion Group and Prediction Section.



Since the Director sights are stabilized to keep them on the Target during the roll and pitch of the Ship, the Director continuously measures Director Elevation, *Eb*.

Director Elevation, *Eb*, is the angle between the deck plane and the Line of Sight, measured in the vertical plane through the Line of Sight. *Eb* is transmitted electrically to the *Eb* Receiver in the Synchronize Elevation Group in the Computer.

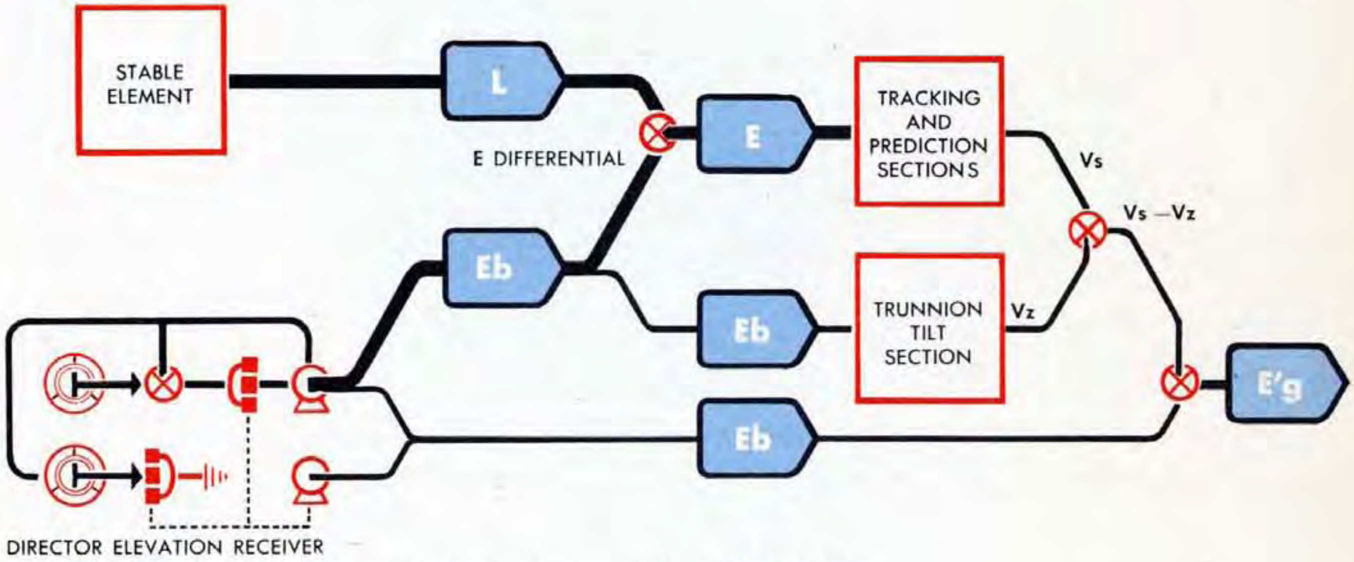
Target Elevation, *E*, is the angle between the horizontal and the Line of Sight, measured in a vertical plane through the Line of Sight.



Director Elevation, *Eb*, consists of Target Elevation, *E*, plus Level, *L*. Level, *L*, is the angle between the horizontal plane and the deck plane, measured in the vertical plane through the Line of Sight.

The value of Target Elevation, *E*, is computed at the *E* Differential where the value of *L* from the Stable Element is continuously subtracted from *Eb*.

This is the only function of the *E* Differential in Continuous Aim: to provide a continuously correct value of Target Elevation, *E*, by subtracting *L* from *Eb*.



If the Computer had been designed to compute only for Continuous Aim using Director inputs, the Synchronize Elevation Mechanism would not have been needed. Continuous E *from the* E *Differential could simply have been transmitted throughout the Computer by shaft lines.*

A general description of the FUNCTION of the SYNCHRONIZE ELEVATION MECHANISM

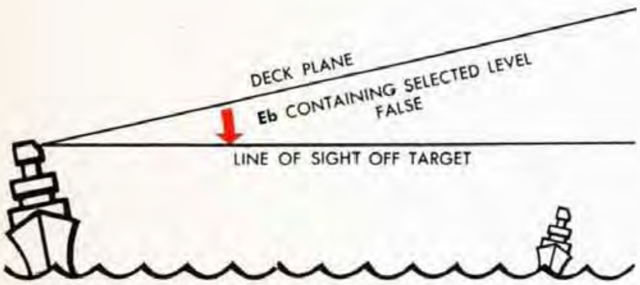
The three jobs of the Synchronize Elevation Mechanism are summarized here and the mechanism is built up schematically. A detailed description of the function and arrangement of the mechanism follows this summary.

The three jobs of the Synchronize Elevation Mechanism are:

1 Adapting the Computer for Selected Level Fire, with Level selected at the Director. This is done by "interrupting" the *E* line in the Computer.

2 Adapting the Computer for use without an input of Director Elevation, *Eb,* from the Director.

3 Restoring the Computer for Continuous Aim, using an input of Director Elevation, *Eb,* from the Director. This is called "synchronizing Elevation."



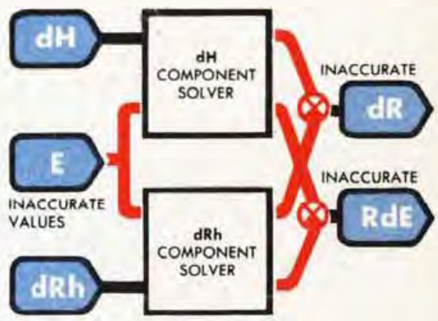
Selected Level Fire, with Level selected at the Director

Selected Fire is used against surface targets when Continuous Aim is impractical. There are several factors which can make Continuous Aim impractical: The values of Level and Cross-level may become larger than the limits of operation of the stabilizing equipment, or various casualties may occur. Also there are a number of situations in which Selected Fire is required by *ship's doctrine.*

One type of Selected Fire is Selected Level Fire, with Level selected at the Director. In this type of fire the Director sights are not continuously leveled to remain on the Target, but incline with the deck. Since the crosshairs of the sights are swept up and down across the Target by Own Ship Motion the value of *Eb* at the Director is inaccurate except at the moment when the Pointer's crosshair is actually on the target.

The selected value of *L* may be varied at will, even within one roll, to permit a higher rate of fire.

1. Adapting the Computer for Selected Level Fire, with Level selected at the Director



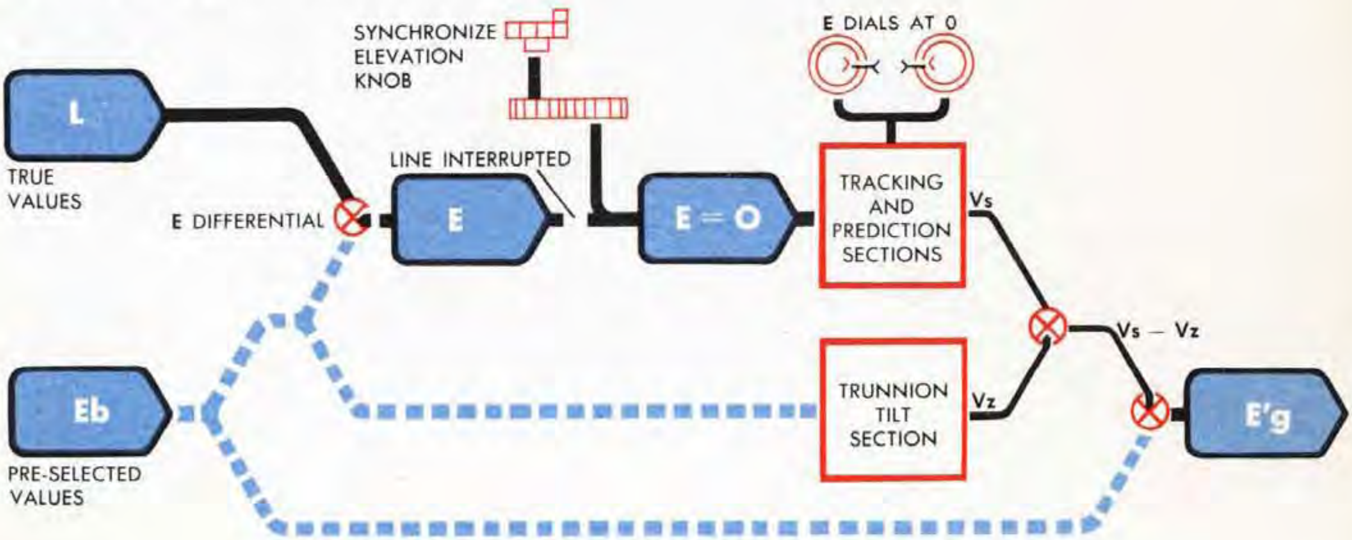
When the inaccurate values of *Eb* from the Director are received in the Computer, they combine with values of *L* at the *E* Differential and produce inaccurate values of *E*.

The inaccurate values of *E* must not be allowed to enter the Tracking or Prediction Sections of the Computer. In the Relative Motion Group of the Tracking Section they would cause false values of *dR* and *RdE* to be computed, resulting in false values of Generated Range, *cR*, and other generated quantities. In the Prediction Section the inaccurate values of *E* would produce false Prediction outputs.

There are therefore two problems in adapting the Computer for Selected Level Fire, with Level selected at the Director: The first problem is to keep the inaccurate values of *E* out of the Tracking and Prediction Sections. The second is to provide a substitute value of *E* in place of the continuous correct *E* needed by these sections.

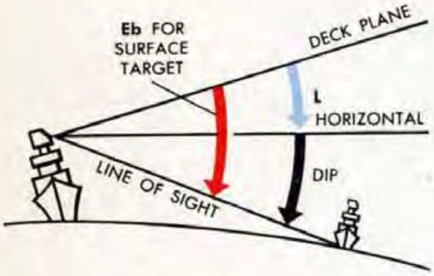
The inaccurate *E* is kept out of the Tracking and Prediction Sections by "interrupting" the *E* line. This is done by means of a differential, which is described later. The effect of using this differential is the same as if a shaft were removed on the *E* line.

The substitute value of *E* is provided by means of a handcrank called the Synchronize Elevation Knob, which is used to position the *E* line to the Tracking and Prediction Sections. The value of *E* at which the line is positioned is zero, since Selected Level Fire is only used against surface targets, for which the actual *E* is always close to zero. As long as the actual value of *E* is within about 3 degrees of zero, a zero *E* is sufficiently accurate for use in the Computer.



2. Adapting the Computer for use without an input of Eb from the Director

It is possible to fire without the aid of the Director Elevation input, *Eb*, by positioning the Computer *E* and *Eb* shafting at the Computer itself.



There are two main reasons why this arrangement is desirable:

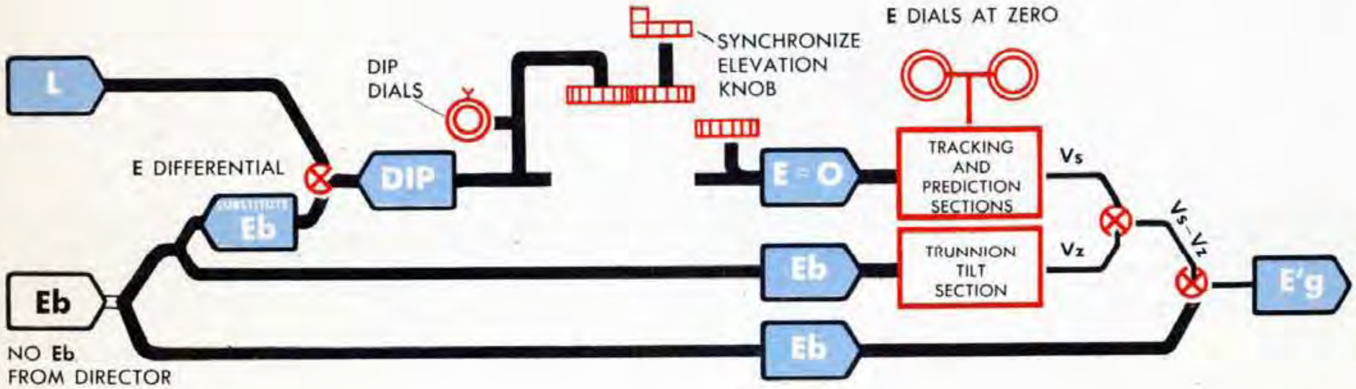
1 To allow for CASUALTIES. The Director may suffer casualties which will cut off the three main Director inputs to the Computer, namely *R*, *B′r* and *Eb*. In order to use the Computer, substitutes must be provided. Values of Range, *R*, and Relative Bearing, *B r*, may be obtained from some other source and set into the Computer directly. The substitute value of *Eb*, however, must be computed.

2 To provide greater FLEXIBILITY. There are several types of firing, including shore bombardment and blind firing, in which it is often preferable to compute a substitute value of *Eb* at the Computer rather than to measure *Eb* from the Director. Sometimes *Eb* cannot be measured from the Director and therefore *must* be computed. The Director may continue to supply *R* and *B′r*, or the values of these quantities may come from some other source as specified by *ship's doctrine*.

The substitute value of *Eb* used in the Trunnion Tilt Section and in Gun Elevation Order is computed with the aid of the Dip Dials in the Synchronize Elevation Mechanism. The Dip Dials compute a negative value of Target Elevation, *E*. This negative value of *E* is called Dip.

The Dip Dials are graduated in such a way that when they are matched and set at the value of Range, the *E* line going to the *E* Differential is positioned at the correct Dip angle.

Dip is set into the Computer by using the Synchronize Elevation Knob. At the *E* Differential the value of Dip is combined with *L* from the Stable Element to form a substitute value of *Eb* for use in the Trunnion Tilt Section and the Gun Elevation Order.



3. Restoring the Computer for Continuous Aim

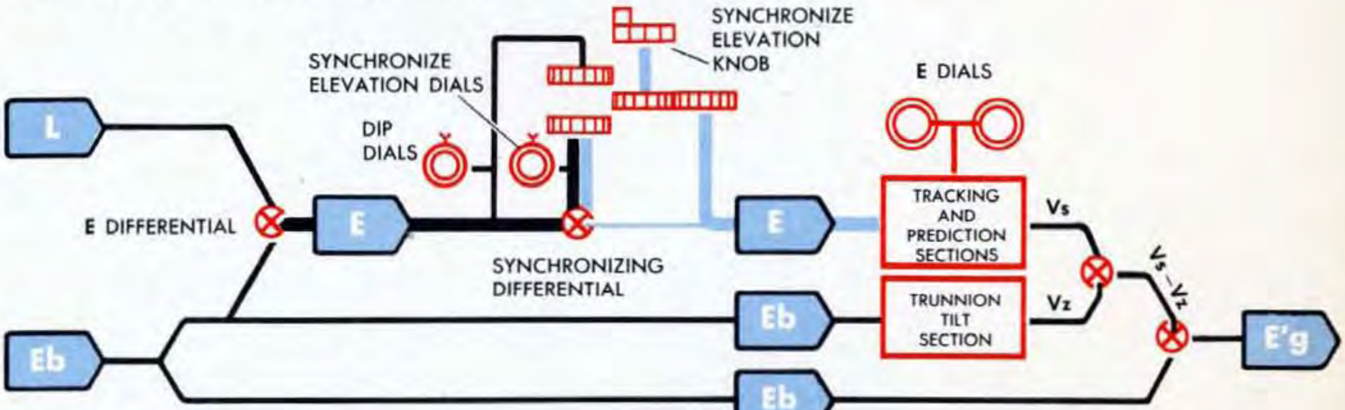
The synchronizing differential

The *E* line must be interrupted in order to prevent inaccurate values of *E* from entering the Tracking and Prediction Sections. It must also be put together again in order that the Computer may compute for Continuous Aim. To allow the line to be interrupted and restored easily, the *E* line is interrupted by means of a differential rather than by removal of a shaft. The differential used is differential D-12 and is called the "synchronizing differential."

The spider of the synchronizing differential is connected to the *E* line going to the Tracking and Prediction Sections. A branch of this line can be connected to the Synchronize Elevation Knob.

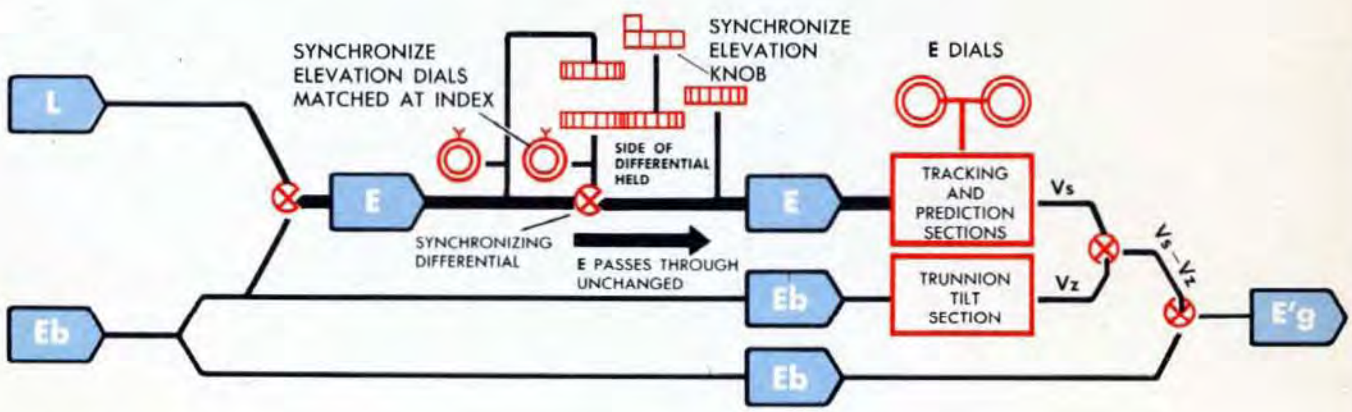
Interrupting the E LINE

When the *E* line going to the Tracking and Prediction Sections is connected to the Synchronize Elevation Knob, the *E* line is interrupted. Values of *E* from the *E* Differential come in on one side of D-12 and back out on the other side, rotating a set of dials called the Synchronize Elevation Dials. The required value of *E* is set into the Tracking and Prediction Sections by the Synchronize Elevation Knob.



Restoring the E LINE

When the side of D-12 connected to the Synchronize Elevation Dials is held by the Synchronize Elevation Knob, rotation of the other side of D-12 rotates the spider. The differential acts as a direct gear drive. To equalize the values of *E* coming in and going out of D-12, the Synchronize Elevation Dials are matched and held at their fixed index. The *E* lines then turn as a single line and are said to be synchronized.

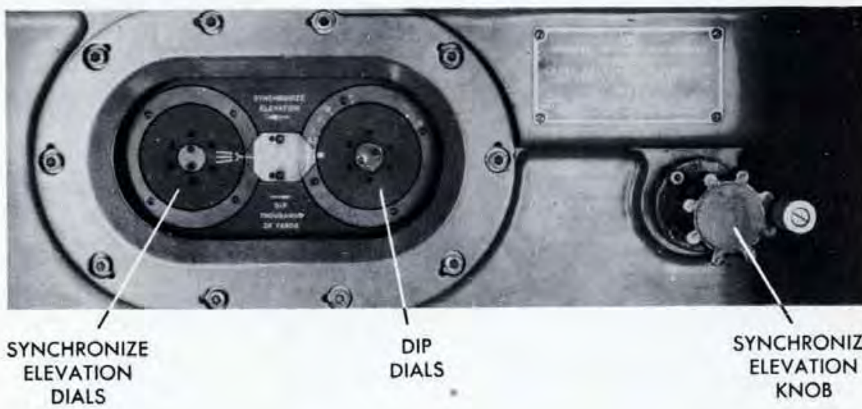


The SYNCHRONIZE ELEVATION MECHANISM

The Synchronize Elevation Mechanism includes the Synchronize Elevation Knob, the Synchronize Elevation Dials, the Dip Dials, the synchronizing differential D-12, two brakes on differential D-12, and a push-button switch.

The Synchronize Elevation Dials

The Synchronize Elevation Dials consist of an inner and an outer dial with planetary gearing between them. These dials have index marks but no numbers. These marks must be matched at the fixed index for normal operation.

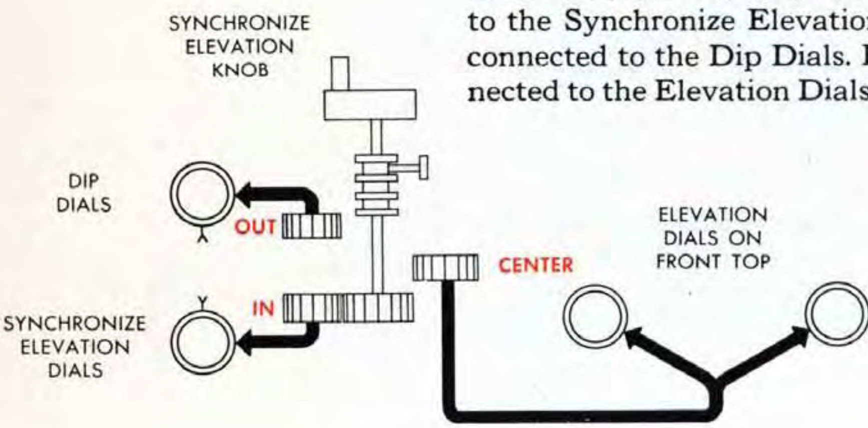


The Dip Dials

The Dip Dials consist of an inner and an outer dial connected by planetary gearing. The inner dial has one broad white mark on it. The outer dial has uneven calibrations in thousands of yards of Range, from 0.5 to infinity.

The Synchronize Elevation Knob

The Synchronize Elevation Knob has three positions: IN, CENTER, and OUT. In its IN position, the knob is connected to the Synchronize Elevation Dials. In its OUT position, it is connected to the Dip Dials. In its CENTER position, it is connected to the Elevation Dials on the front top of the Computer.



The Differentials and Brakes

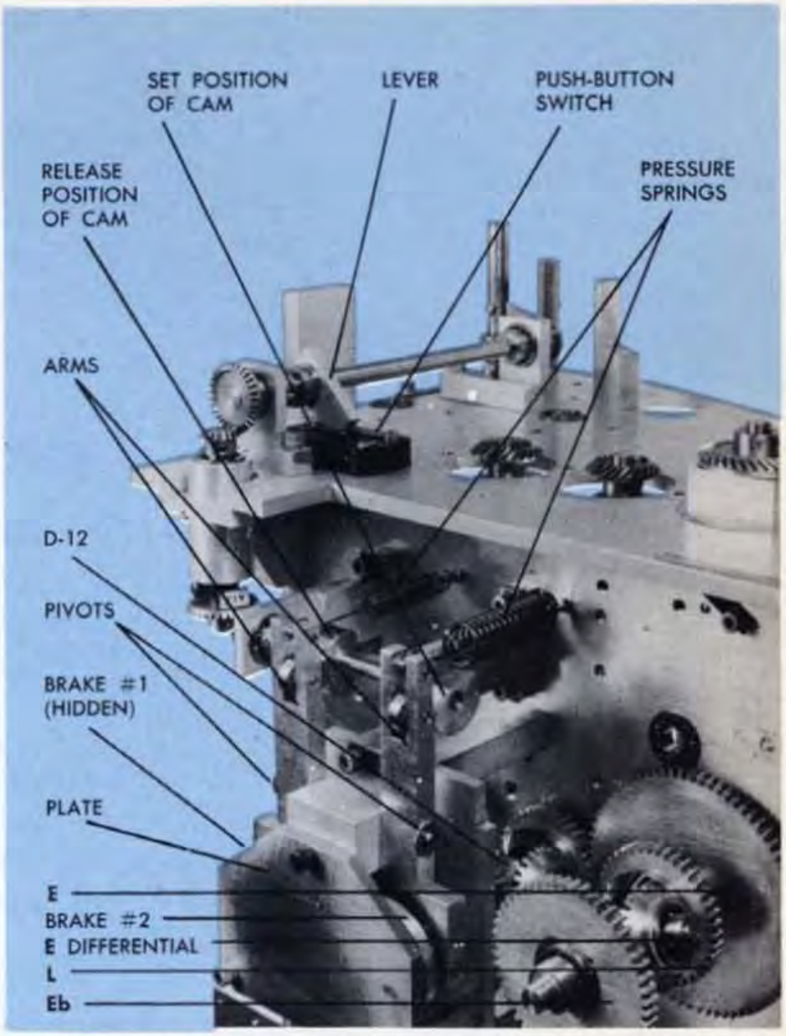
This drawing shows the relative positions of the *E* Differential and differential D-12, and the arrangement of the two brakes.

The output gear on the spider of the *E* Differential meshes with one input gear of D-12. The other input gear of D-12 meshes with a gear on the shaft carrying brake #1. Brake #2 is on the spider of D-12.

The brakes are cork-faced disks, spline-coupled to the shaft.

When a brake is released, the cork-faced disk turns freely with its shaft. When a brake is set, the cork face is pressed against a stationary plate. The friction between the cork face and the plate puts a drag on the shaft. However, it is still possible to turn the shaft by means of the Synchronize Elevation Knob.

The brakes are positioned by arms which are operated through cams at the tops of the arms. Either brake is set by the spring on its arm, unless released by its cam. These cams are arranged in such a way that when one brake is set,the other is released.



POSITION OF BRAKES WHEN THE SYNCHRONIZE ELEVATION KNOB IS OUT

The position of the Synchronize Elevation Knob controls the brakes by moving a lever which turns the shaft holding the cams. The cams pivot the arms. When one of the arms pushes a brake against the plate, the other arm pivots in the opposite direction, moving the other brake away from the plate. The released brake turns with its shaft.

The Push-button Switch

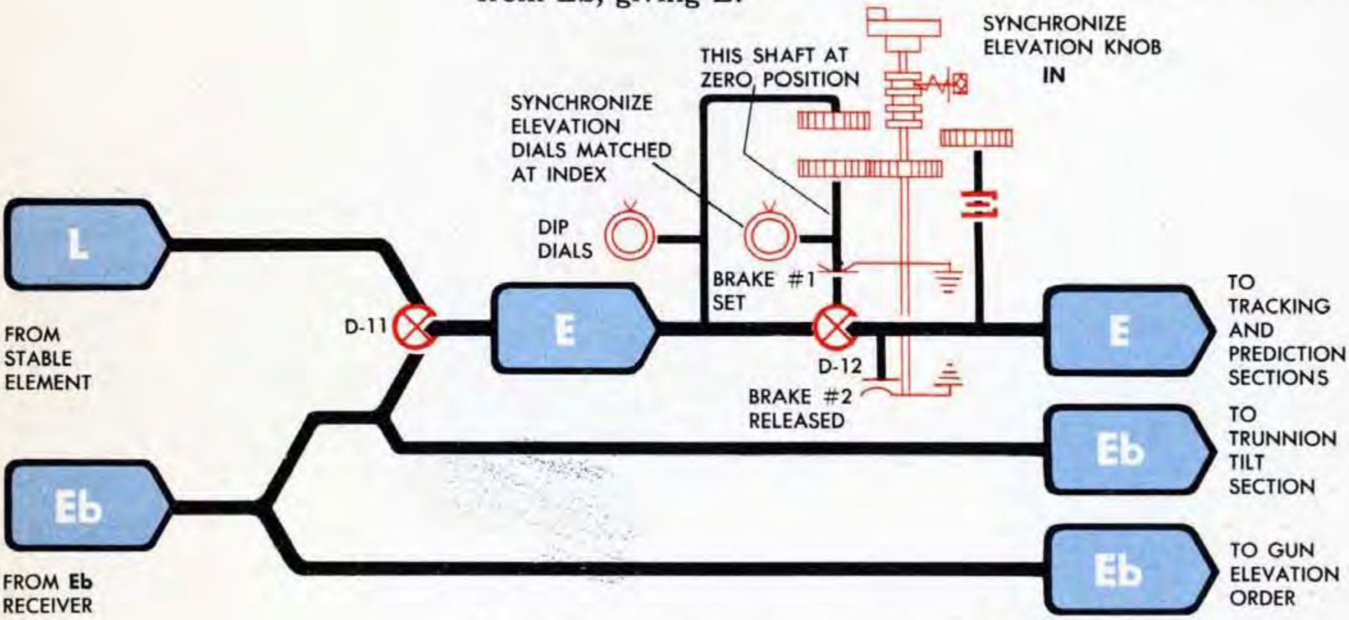
The push-button switch is controlled by a lever moved by the Synchronize Elevation Knob. Pulling the knob to its OUT position moves the lever and presses the push-button. This cuts out the Director Elevation Receiver, by de-energizing the *Eb* Follow-up Servos.

The Elevation Lines in Continuous Aim

In Continuous Aim with the Director operating, continuous *Eb* is needed in the Trunnion Tilt Section and for making up Gun Elevation Order. Continuous *E* is needed in the Tracking and Prediction Sections.

Eb from the Director is continuously received at the *Eb* Receiver. Two servo motors in this receiver position the *Eb* line. One part of the *Eb* line goes directly to form the Gun Elevation Order, *E′g*. Another part of the *Eb* line branches into a line going to the Trunnion Tilt Section and a line going to the *E* Differential.

At the *E* Differential, *L* from the Stable Element is subtracted from *Eb*, giving *E*.



The Synchronize Elevation Mechanism on the *E* line is positioned to allow *E* to pass through differential D-12 unchanged. The Synchronize Elevation Knob is in its IN position. Putting the knob IN sets brake #1 on the side gear of D-12 and releases brake #2 on the spider of D-12.

The Synchronize Elevation Knob has been turned in its IN position until the Synchronize Elevation Dials match at their fixed index. Turning the knob in its IN position turns the side gear of D-12 against the friction of brake #2. This motion backs out on the spider of D-12 and synchronizes the *E* line by making the value of *E* going to the Tracking and Prediction Sections equal to the value of E coming from the E Differential, D-11.

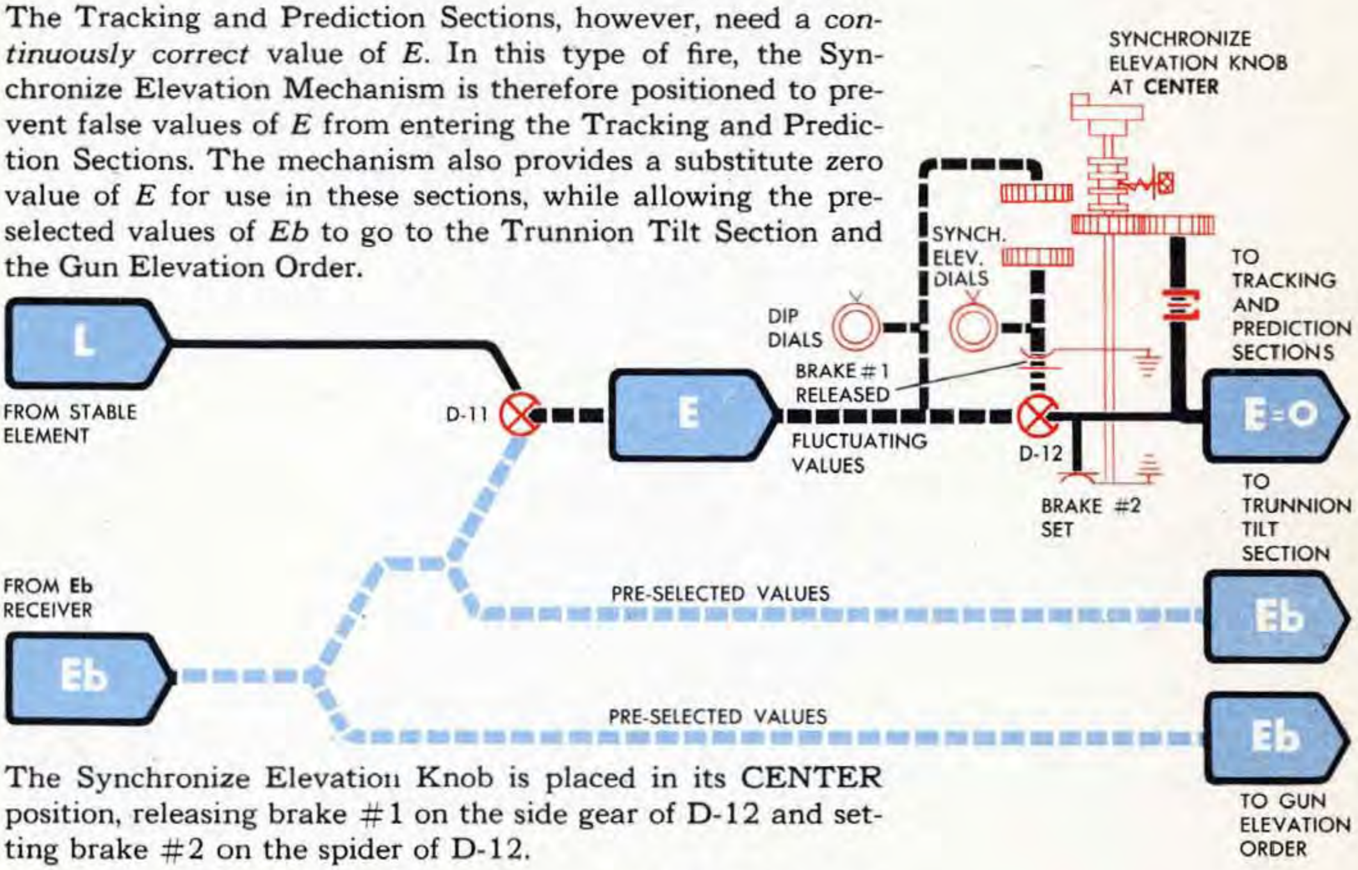
For Continuous Aim with the Synchronize Elevation Knob in its IN *position, the whole Synchronize Elevation Group may be thought of as a single differential, D-11, where* L *is continuously subtracted from* Eb *to form* E.

The Elevation Lines in Selected Level Fire, with Level selected at the Director

In Selected Level Fire, with Level selected at the Director, the Director sights are not "leveled," but are positioned at some pre-selected angle to the deck. The crosshairs therefore sweep across the target as the deck rolls or pitches, and the value of *Eb* is false except at the moment that the Pointer's crosshair is on the Target.

At the moment that the crosshair *is* on the Target, the selected Level equals the actual Level and the value of *Eb* is correct. In order for the guns to be correctly pointed at this moment, the pre-selected value of *Eb* is transmitted to the Computer for use in the Trunnion Tilt Section and the Gun Elevation Order.

The Tracking and Prediction Sections, however, need a *continuously correct* value of *E*. In this type of fire, the Synchronize Elevation Mechanism is therefore positioned to prevent false values of *E* from entering the Tracking and Prediction Sections. The mechanism also provides a substitute zero value of *E* for use in these sections, while allowing the pre-selected values of *Eb* to go to the Trunnion Tilt Section and the Gun Elevation Order.



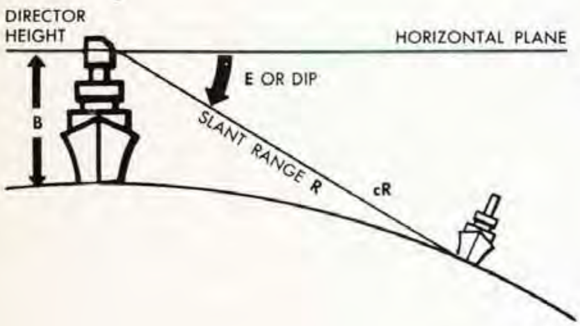
The Synchronize Elevation Knob is placed in its CENTER position, releasing brake #1 on the side gear of D-12 and setting brake #2 on the spider of D-12.

The pre-selected values of *Eb*, received at the *Eb* Receiver, position the *Eb* lines to the Trunnion Tilt Section, the Gun Elevation Order, and the *E* Differential.

At the *E* Differential, true values of *L* are subtracted from pre-selected values of *Eb*, giving inaccurate values of *E*. These values of *E* position one side gear of D-12, but since brake #2 is set, they merely back out through the other side gear of D-12 and turn the Synchronize Elevation Dials.

With the Synchronize Elevation Knob, the *E* line to the Tracking and Prediction Sections is turned until the Target Elevation Dials on the front of the Computer read zero.

The Elevation Lines in Firing without a Director



The Computer Mark 1 may be used without a Director for controlling fire against a surface target.

Since the computation of Gun Elevation Order is based on the angle *Eb*, a substitute value of *Eb* must be provided when the Director is not used. This substitute value of *Eb* must closely approximate the value ordinarily supplied by the Director

The substitute value of *Eb* is composed of Level, *L*, from the Stable Element, plus Dip, the negative value of *E* based on the Director position.

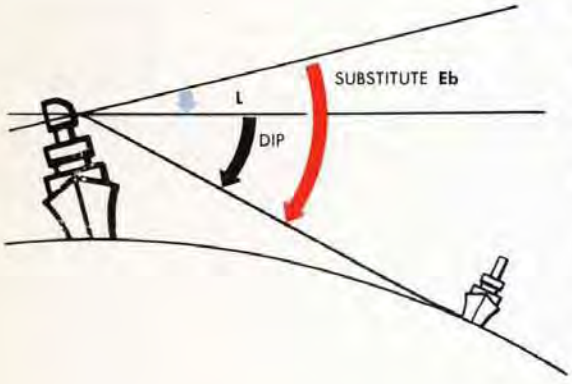
In the Computer Mark 1, Dip is computed by this equation:

$$\text{Dip} = \sin^{-1} \frac{2AB + B^2 + R^2}{2(A+B)R}$$

where R = Slant Range to the Target, in yards
A = means radius of the earth, in yards
B = Director Height above the waterline, in yards

Because this equation contains only one variable, *R*, no computing mechanism is necessary except the Dip Dial, which is calibrated in suitable graduations.

Although the equation is set up for slant range, general practice is to use *R2* because of the convenient location of the *R2* Counter to the Dip Dial and Knob. This is permissible because of the very negligible error in the computation of Dip for a surface problem where *R2* is substituted for *cR*.



The graduations on the Dip Dial are spaced so that, when the value of Range is at the fixed index, the *E* line is positioned at the corresponding value of Dip. This angle of Dip is a substitute for the angle through which the Director Line of Sight would have to be depressed from the horizontal in order to meet the waterline of the Target.

Dip is set into the *E* line with the Synchronize Elevation Knob in its OUT position. The Dip value is combined with the selected value of Level from the Stable Element, in differential D-11. This differential positions the *Eb* shafting to a value conforming to the value it would have if the Director were in control.

The *E* line on the other side of differential D-12 is held fixed at zero in order to furnish zero Elevation to the Tracking and Prediction Sections as in Selected Level Fire.

Setting up for Dip

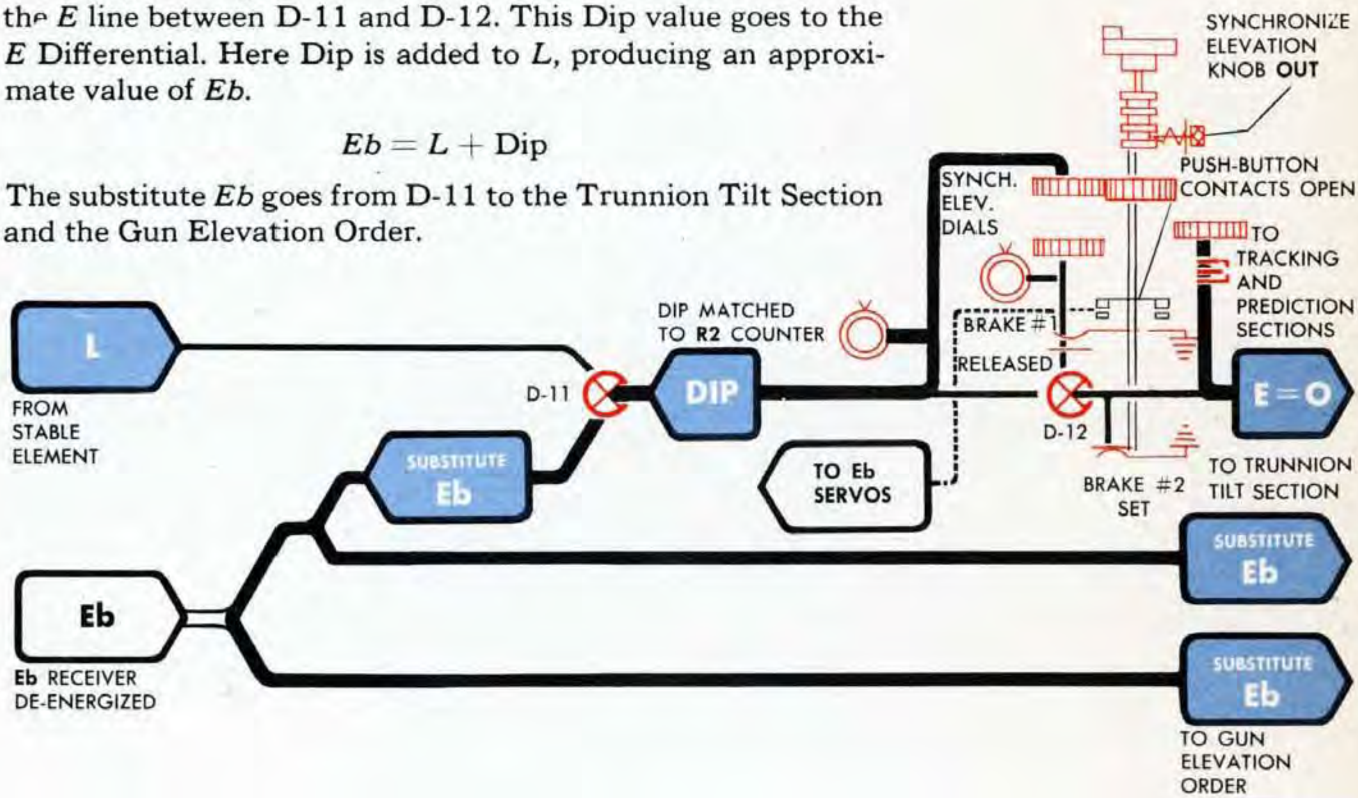
In adapting the E lines in the Computer for operation without a Director, the Synchronize Elevation Knob is first put in its CENTER position. This releases brake #1 and sets brake #2, "interrupting" the E lines. The knob is then turned until the E line going to the Tracking and Prediction Sections is positioned at zero. The zero is read on the E Dials on the front of the Computer.

The knob is next pulled to its OUT position. This does not change the position of the brakes; therefore the E line to the Tracking and Prediction Sections remains at zero. Pulling the knob OUT moves a lever which depresses a push-button, de-energizing the Eb Receiver. In its OUT position the Synchronize Elevation Knob is connected to the Dip Dials and the E line between D-11 and D-12. The knob is turned in this position until the Dip Dial reading is matched to the value on the $R2$ Counter.

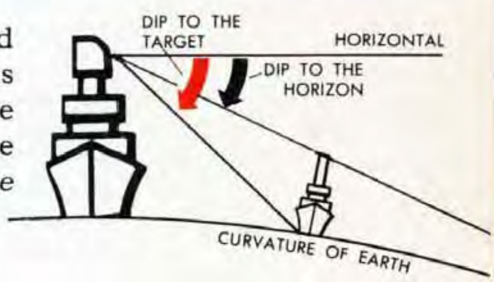
Matching the Dip Dial reading to $R2$ puts a value of Dip into the E line between D-11 and D-12. This Dip value goes to the E Differential. Here Dip is added to L, producing an approximate value of Eb.

$$Eb = L + \text{Dip}$$

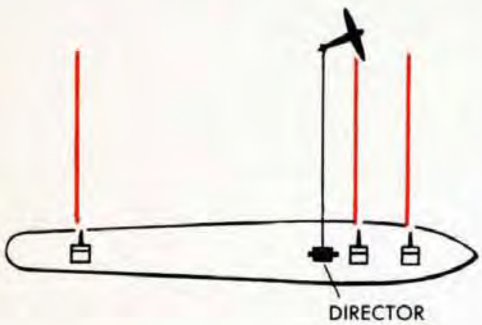
The substitute Eb goes from D-11 to the Trunnion Tilt Section and the Gun Elevation Order.

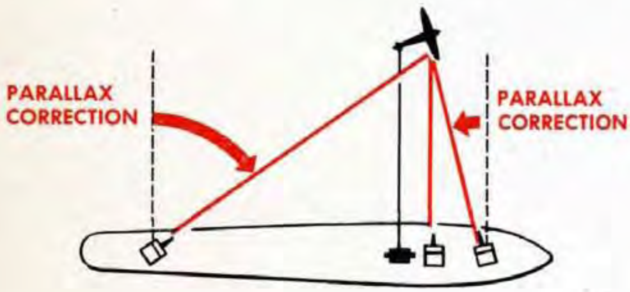


Dip to the Target is the angle between the horizontal and a Line of Sight *to the waterline of a surface target*. This should not be confused with Dip to the horizon, which is the angle between the horizontal and a Line of Sight to the horizon. Whenever Dip is mentioned in this book *Dip to the Target* is meant unless otherwise specified.



PARALLAX





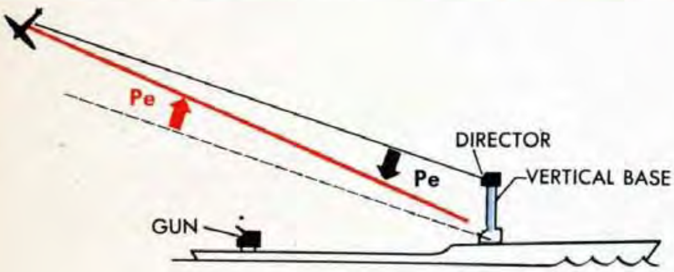
The Gun Elevation and Gun Train Orders computed by the Computer Mark 1 are based on observations made from a Director. These orders are correct for guns located at that Director.

But if these same Gun Orders are used to position guns located at a distance along the deck from the Director, the projectiles from these guns will travel *parallel* to the projectiles from the guns near the Director and will not hit the Target.

Angular corrections to the guns are required when the point of fire is separated from the point of observation. These corrections are called Parallax Corrections. These Parallax Corrections cause the Lines of Fire from the various guns to converge at the Target. Directors, as well as guns, may receive Parallax Corrections, for reasons which will be explained in this chapter.

The Computer Mark 1 computes three Parallax Corrections: one is used by the guns only; the other two may be used by both guns and Directors.

Pe: Elevation parallax correction for vertical base



If the guns down on the deck were aimed at the same Elevation angle as the Director, their projectiles would burst below the Target. Elevation Parallax Correction, *Pe,* is a positive Elevation Correction to compensate for this difference in *height* between the Director and the guns.

Nearly all Directors are assumed to be 30 feet above the guns. *Pe* is used by the guns only.

Pe is computed in the *Vf* + *Pe* Ballistic Computer and is included in Gun Elevation Order, *E'g,* coming from the Computer Mark 1.

NOTE:
The diagrams in this chapter exaggerate the parallax angles because the ranges shown are necessarily short. Actually all Parallax Corrections are relatively small angles which change the Elevation and Train of the guns only slightly. Also these diagrams show the guns pointed directly at the Target. All predictions have been omitted.

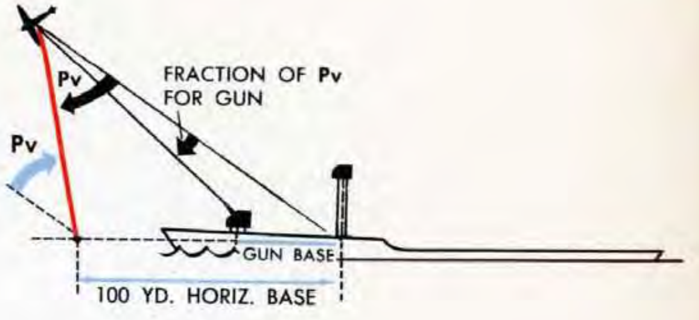
Pv: Elevation parallax correction for horizontal base

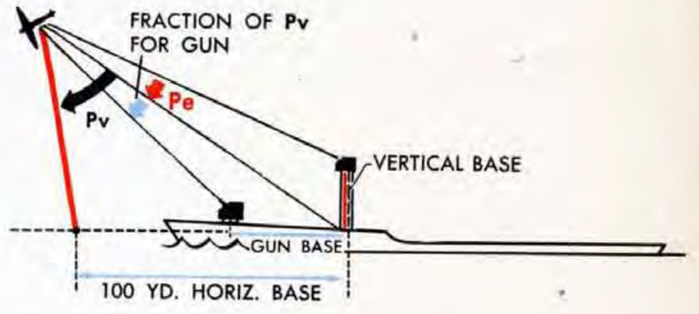
Unlike Elevation Parallax Correction, *Pe,* which is for a *vertical* base, Elevation Parallax Correction, *Pv*, is for a *horizontal* base.

The guns are located along the deck at varying distances from the Director.

A gun at a great distance from the Director will need a correction to Elevation in order to hit the Target. This correction is called Elevation Parallax, *Pv*. The amount of correction needed by the gun will depend on the gun's distance from the Director. The Computer Mark 1 computes one *Pv* unit parallax correction for a 100-yard horizontal base forward of the Director. The gun uses a fraction of this computed correction corresponding to its distance from the Director.

Here are *Pe* and *Pv*, the two Elevation Parallax Corrections.





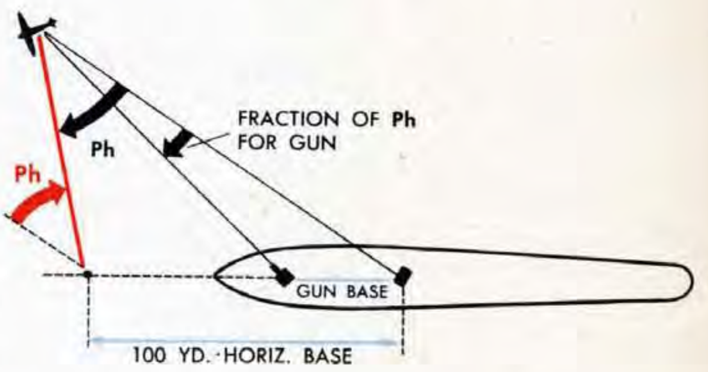
Ph: Train parallax correction for horizontal base

Because of the different locations of the guns along the deck from the Director, each gun needs a *train* parallax correction.

This train correction is called Train Parallax Correction, *Ph*.

As in the case of *Pv,* the Computer Mark 1 computes a unit Train Parallax Correction, *Ph,* for a 100-yard horizontal base forward of the Director. Then each gun uses a fraction of this unit parallax correction corresponding to its distance from the Director.

Pv and Ph are not included in the Computer Gun Orders, but are transmitted separately to the mounts. Change gears are used at each gun mount to obtain the proper fraction of each unit correction. These fractions are then added to the Gun Orders. Pv is added to Gun Elevation Order, E'g. *Ph is added to Gun Train Order*. B'gr.



NOTE:
Elevation Parallax Correction, *Pv,* is used by only a few gun installations.

Train Parallax Correction, Ph, is used by most gun installations.

On ships having two or more Directors, *Ph* is usually sent to the Directors.

In a few installations, *Pv* is also sent to the Directors.

How the PARALLAX corrections are used

To make the Gun Director Mark 37 System flexible, the Computer Mark 1 solves the fire control problem on the assumption that all directors and guns are located at one point on the deck. This point is called the *Reference Point*.

When there is only one Director on a ship, the Director is considered to be the Reference Point. The aim of each mount is corrected to allow for the distance of the mount from the Reference Point.

When there is more than one Director, the Reference Point may be a Director or a designated point.

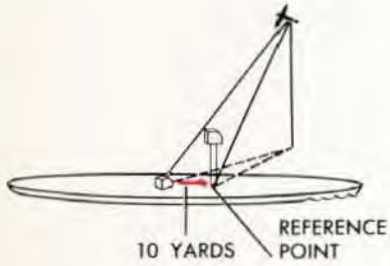
Correcting GUNS for parallax

The guns can be corrected by one or both of the unit Parallax Corrections calculated for a 100-yard horizontal base:

Elevation Parallax Correction, *Pv*
Train Parallax Correction, *Ph*

Each gun uses the fraction of each correction it needs, depending on its distance from the Reference Point.

How fractions of Ph and Pv are used



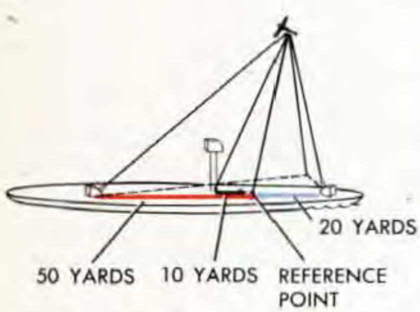
On the ship shown in the first illustration, the Director is the Reference Point, and therefore needs no correction.

The gun on the afterdeck is 10 yards from the Reference Point. Since 10 yards is 1/10 of 100 yards, this gun will use 1/10 of the *Ph* and *Pv* values from the Computer.

On the ship shown in the second illustration, the Reference Point is a designated point forward of the center of the ship.

The gun on the afterdeck is 50 yards from the Reference Point. Since 50 yards is 1/2 of 100 yards, this gun will use 1/2 of *Ph* and *Pv*.

The Director is 10 yards abaft the Reference Point. It uses 1/10 of the *Ph* correction.



The gun on the forward deck is 20 yards from the Reference Point. It uses 1/5 of the *Ph* and *Pv* corrections.

The guns forward of the Reference Point or Director use the Parallax Corrections in the direction in which they are computed. The guns aft of the Reference Point or Director reverse the direction of the corrections.

This example merely illustrates how *Ph* and *Pv* can be used to correct the gun orders. Guns near the Reference Point usually receive no *Ph* or *Pv* corrections.

Correcting DIRECTORS for parallax

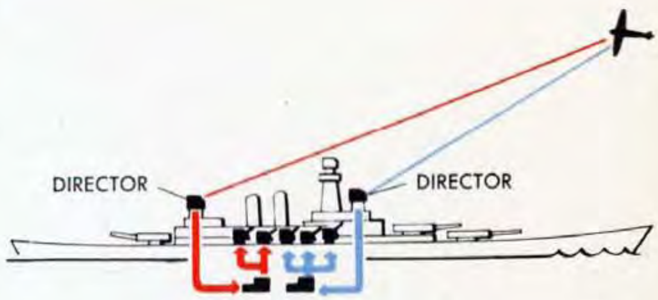
Why the directors are corrected

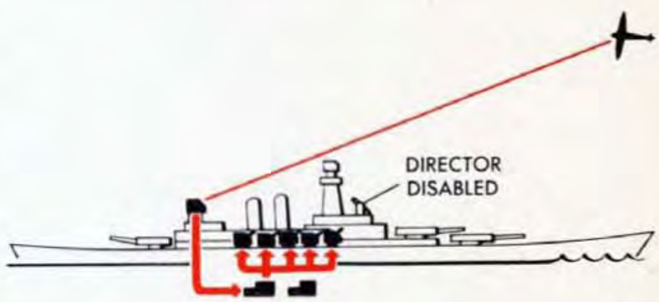
Each Director sends observations of Range, Director Elevation, and Director Train to a Computer Mark 1. Each Computer Mark 1 then computes Gun Orders for the guns connected to it. If one Director is disabled, the guns using Gun Orders based on its observations can be quickly connected to a Computer working with another Director.

Since the Directors are located at different points along the deck, each Director observes a slightly different angle of Director Train, *B′r,* for the same Target.

It is desirable to have these transmitted values of *B′r* uniform, so that any Director can supply *B′r* to any Computer.

To make the values of *B′r* uniform, all Directors must be corrected to one Director or to a Reference Point. This is done by using Train Parallax Correction, *Ph,* at the Directors.



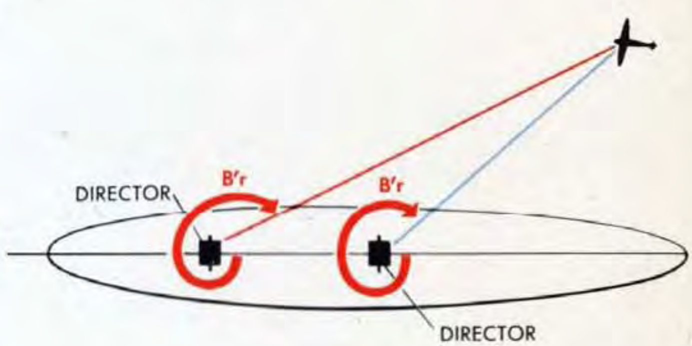


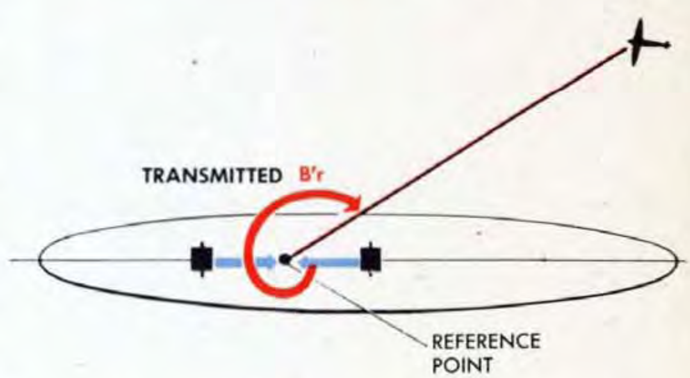
How the directors are corrected

Each Director takes the fraction of the *Ph* correction corresponding to its distance from the Reference Point, and adds this fraction to its observed value of *B′r*.

After the Directors have used the *Ph* correction, the values of *B′r* coming from all Directors will be identical for any one Target.

In the Gun Director Mark 37 System, Observed Range is not corrected to a Reference Point. Director Elevation is corrected to a Reference Point in only a few installations where Directors are widely separated.





B′r FROM EACH DIRECTOR IS CORRECTED TO THE REFERENCE POINT

A summary of the PARALLAX CORRECTIONS

Two factors make Parallax Corrections necessary:

1 The height of the Director above the guns (vertical base)

2 The horizontal distance between the Reference Point and the guns (horizontal base)

These two factors require three Parallax Corrections. Of the three Parallax Corrections, one compensates for the vertical base and two compensate for the horizontal base.

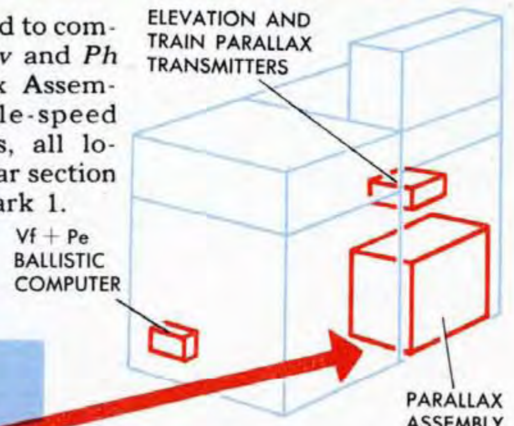
1 Elevation Parallax Correction, *Pe*, corrects for a ten-yard vertical base.

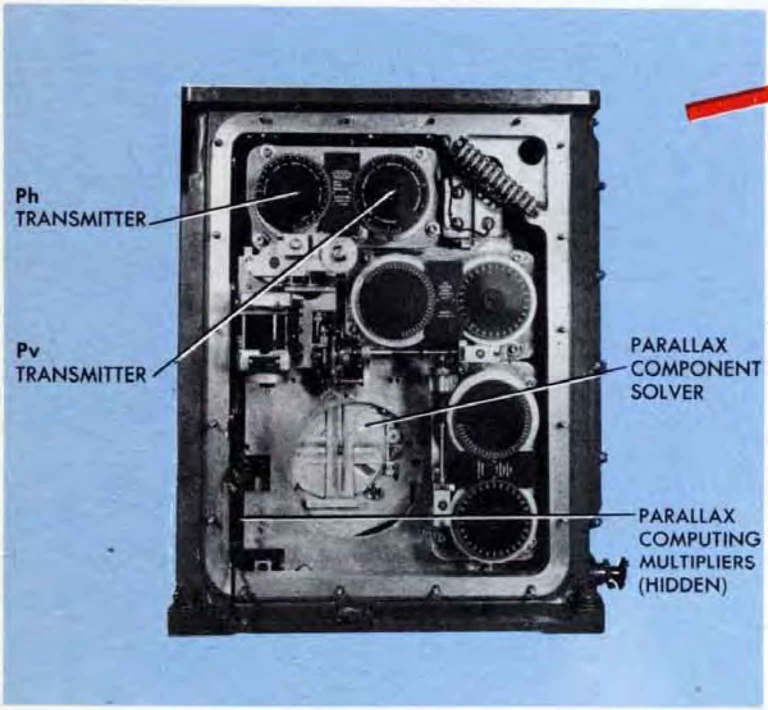
2 Elevation Parallax, *Pv*, and

3 Train Parallax, *Ph*, correct for a 100-yard horizontal base.

The mechanisms for computing Parallax

The mechanisms used to compute and transmit *Pv* and *Ph* include the Parallax Assembly and two single-speed synchro transmitters, all located in the lower rear section of the Computer Mark 1.



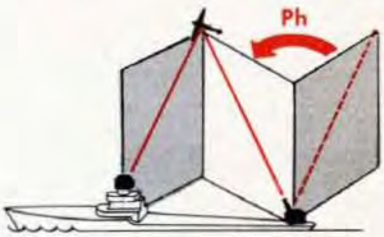


The Parallax Assembly contains the Parallax Component Solver and two computing multipliers.

Elevation Parallax Correction, *Pe*, is computed in the *Vf* + *Pe* Ballistic Computer and is transmitted to the guns as part of Gun Elevation Order, *E′g*.

Train parallax correction Ph

With the guns trained at the same angle as the Director sights, the additional angle of Gun Train needed to put the guns on the Target is *Ph*.



Train Parallax, *Ph*, is computed from three quantities:

1. Gun Train Order, $B'gr$ (or Director Train, $B'r$)
2. Advance Range, $R2$
3. Predicted Elevation plus Level, $E2 + L$

How B'gr affects Ph

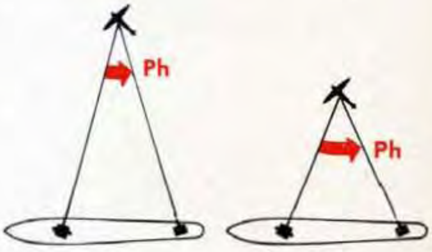
If a Target is directly aft of Own Ship, the angle of Gun Train, $B'gr$, is 180° and the *Ph* correction is zero.

As the Target moves farther abeam of Own Ship, $B'gr$ decreases and *Ph* begins to increase.

Ph varies in proportion to the sine of $B'gr$.

How R2 and E2+L affect Ph

Ph varies as the reciprocal of Range in the deck plane. For long ranges, *Ph* is a small angle. For shorter ranges, *Ph* is a larger angle.



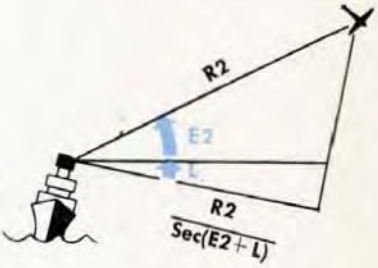
Advance Range, $R2$, is projected onto the deck plane because the gun is trained in that plane.

Finding the value of Range in the deck plane:

$$\sec (E2 + L) = \frac{R2}{\textit{Range in the deck plane}}$$

$$\text{Range in the deck plane} = \frac{R2}{\sec (E2 + L)}$$

Ph, therefore, varies as the reciprocal of $\dfrac{R2}{\sec (E2 + L)}$



Since *Ph* varies as the sine of $B'gr$ and as the reciprocal of $\dfrac{R2}{\sec (E2 + L)}$, the equation for *Ph* is

$$\sin B'gr \times \frac{\sec (E2 + L)}{R2} \times K \cdot 100 = Ph$$

The figure 100 represents the 100-yard horizontal base.

Since it makes no difference which value in the equation is divided by $R2$, the equation is arranged this way for mechanical convenience:

$$\sec (E2 + L) \times \frac{\sin B'gr}{R2} \times K \cdot 100 = Ph$$

NOTE:
This equation for *Ph* is derived fully in the supplement at the end of this chapter.

Two mechanisms solve

The equation for Ph is solved by a component solver and a computing multiplier. The equation is:

$$\sec\,(E2 + L) \times \frac{\sin B'gr}{R2} \times K \cdot 100 = Ph$$

The term $\dfrac{\sin B'gr}{R2}$ is computed in the Parallax Component Solver.

A computing multiplier, called the Train Parallax Computer, multiplies $\dfrac{\sin B'gr}{R2}$ by $\sec\,(E2 + L)$. Constants, K and 100, are introduced by gearing to produce the quantity Ph.

The parallax component solver

The Parallax Component Solver contains a reciprocal cam.

The input to the cam is Advance Range, $R2$. For every input of $R2$ to the cam, the follower pin is pushed to a position representing $1/R2$.

The input to the vector gear is Gun Train Order, $B'gr$.

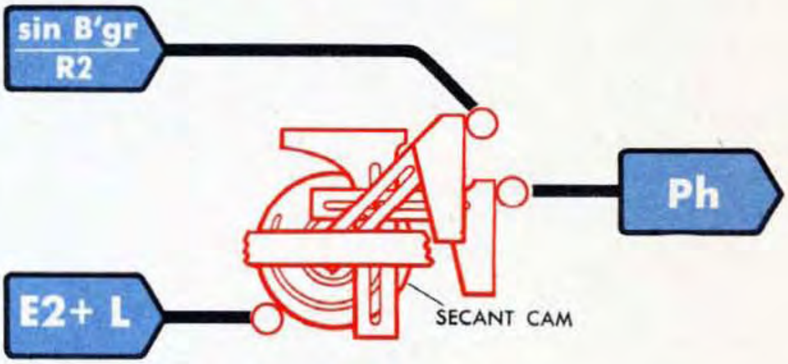
The two outputs of the Parallax Component Solver are:

$\dfrac{\sin B'gr,}{R2}$ which is one of the terms in the equation for Train Parallax, Ph.

$\dfrac{\cos B'gr,}{R2}$ which will be used later as a term in the equation for Elevation Parallax, Pv.

the equation for Ph

The train parallax computer



The Train Parallax Computer is a single-cam multiplier with a secant cam.

The input to the secant cam is $E2 + L$. For every input of $E2 + L$, the input slide moves to a position representing sec $(E2 + L)$.

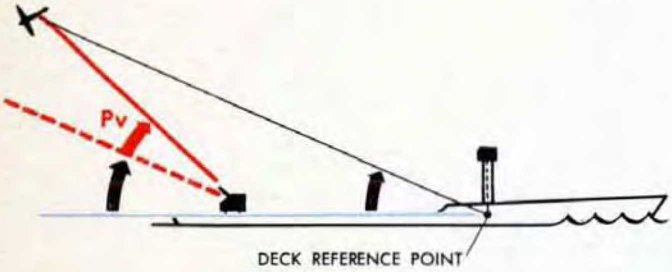
The input to the pivot arm rack is $\frac{\sin B'gr}{R2}$ from the Parallax Component Solver.

The Train Parallax Computer multiplies these two terms together.

Constants K and 100 are taken care of by the choice of gearing to produce the value of Train Parallax Correction, *Ph:*

$$\sec (E2 + L) \times \frac{\sin B'gr}{R2} \times K \cdot 100 = Ph$$

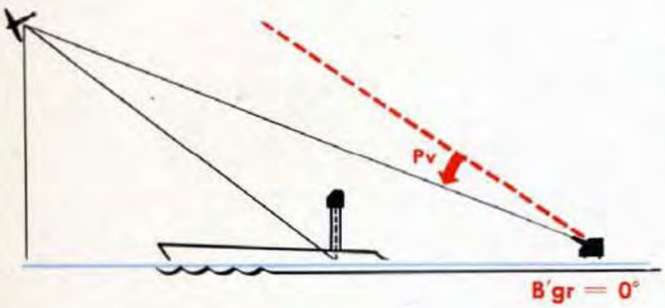
ELEVATION PARALLAX CORRECTION Pv



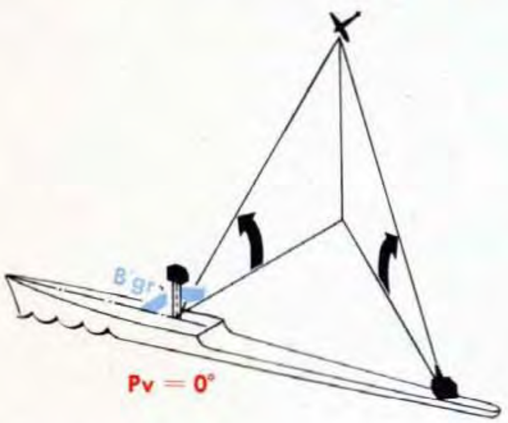
With the guns pointed at the same angle as a line of sight from the Deck Reference Point, the additional angle of Gun Elevation needed to put the guns on the Target is Elevation Parallax Correction, *Pv*.

Elevation Parallax Correction, *Pv*, is computed from three quantities:

1. Gun Train Order, *B′gr*
2. Advance Range, *R2*
3. Predicted Elevation plus Level, *E2 + L*



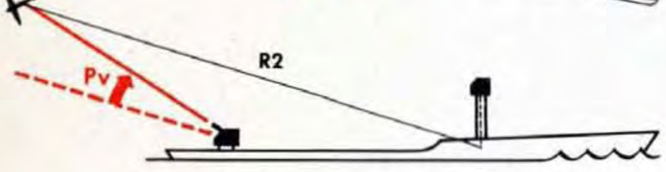
How B′gr affects Pv



Pv varies as the cosine of Gun Train Order, *B′gr*.

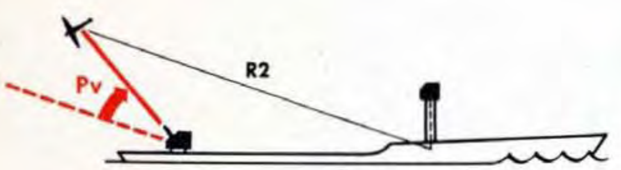
When the Target is directly ahead of Own Ship, *B′gr* is *zero*, and *Pv* is large. Cos $0^\circ = 1.0$.

If the Target is directly abeam of Own Ship, *B′gr* is 90° and *Pv* is zero. Cos $90^\circ = 0$.



How R2 affects Pv

Pv varies inversely as Advance Range, *R2*.



When *R2* is long, *Pv* is a small angle.

When *R2* is short, *Pv* is a larger angle.

How E2 + L affects Pv

When $E2 + L$ is large, Pv is a relatively *large* angle.

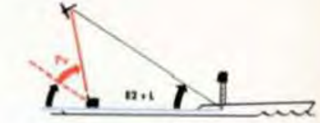
When $E2 + L$ is small, Pv is a *small* angle.

Pv varies as sin $(E2 + L)$.

Since Pv varies as cos $B'gr$, *inversely* as $R2$, and as sin $(E2 + L)$, the equation for Pv is:

$$\sin(E2 + L) \times \frac{\cos B'gr}{R2} \times K \cdot 100 = Pv$$

The term $\frac{\cos B'gr}{R2}$ is one of the outputs of the Parallax Component Solver. This term is multiplied by sin $(E2 + L)$ in a computing multiplier called the Elevation Parallax Computer.



The Elevation Parallax Computer

The Elevation Parallax Computer is a single-cam type multiplier containing a sine cam.

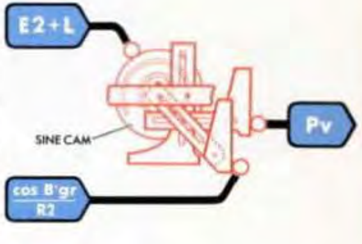
The value of $E2 + L$ positions the sine cam, giving a value of sin $(E2 + L)$ for every input value of $E2 + L$.

The value of $\frac{\cos B'gr}{R2}$ from the Parallax Component Solver is the input to the pivot arm rack.

The Elevation Parallax Computer multiplies one input by the other.

The constants, K and 100, are introduced through gearing to produce the Elevation Parallax Correction, Pv.

$$\sin(E2 + L) \times \frac{\cos B'gr}{R2} \times K \cdot 100 = Pv$$

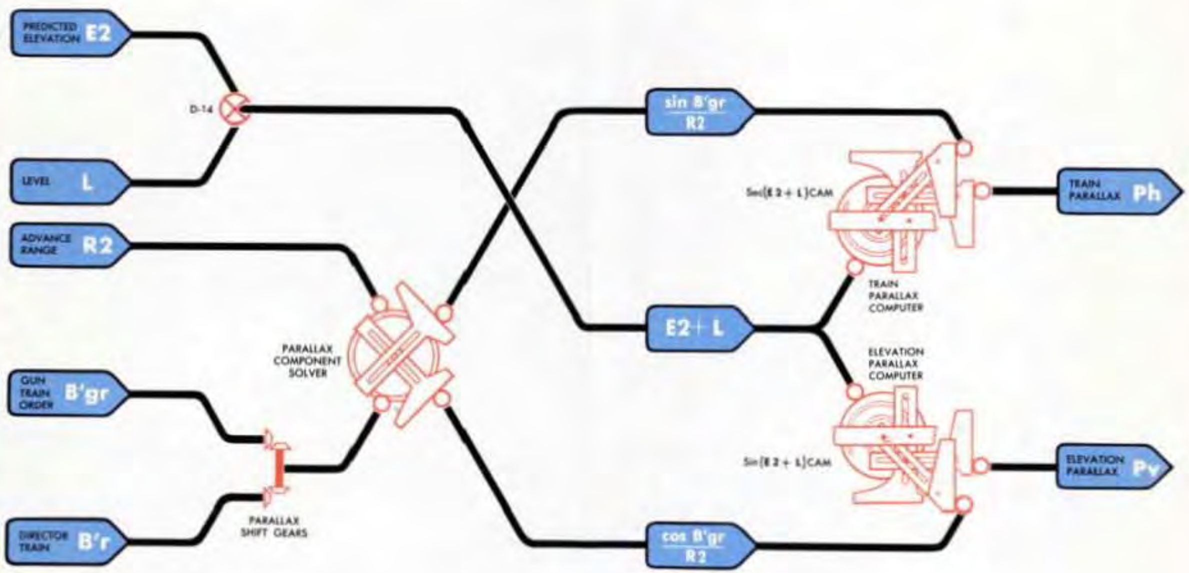


NOTE:
The equation for Pv is derived fully in the supplement at the end of this chapter.

COMPUTER MK. 1, MOD

PARALLAX SECTIO

SCHEMATIC DIAGRAM



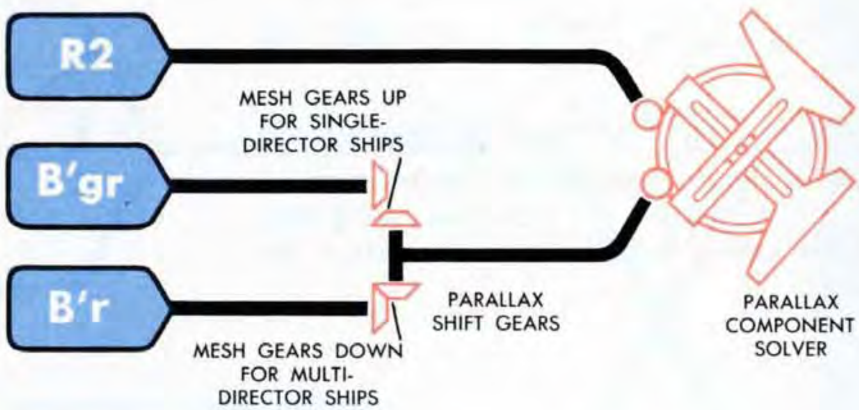
THE PARALLAX SHIFT GEARS

The Parallax shift gears are located on the input line to the vector gear of the Parallax Component Solver. They allow either Gun Train Order, *B′gr,* or Director Train, *B′r,* to be used as the input quantity.

B′gr is used on Single-Director Ships, such as DD's, AO's, and AV's.

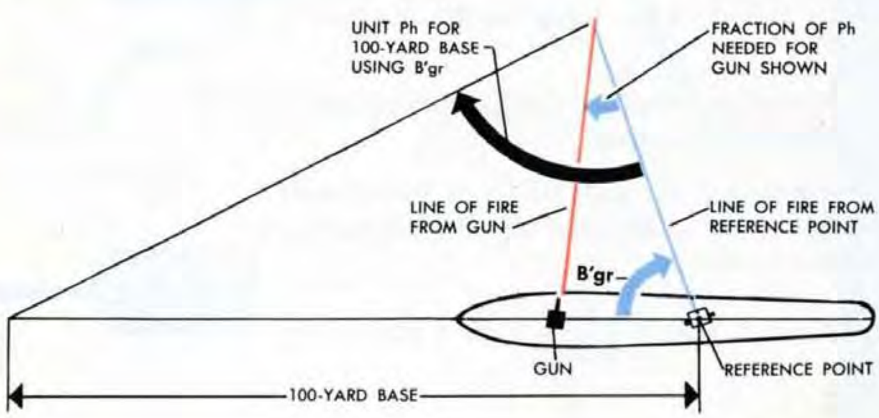
B′r is used on Multi-Director ships, such as BB's, CA's, CB's, and CL's.

Exception: *B′gr* is used on CV's.



Single - Director Ships

On ships with one Director, the Reference Point is always at the Director. Parallax Corrections are needed only to make the Line of Fire from the guns converge with the Line of Fire from the Reference Point. Therefore Gun Train Order, *B′gr,* is the only train angle involved and is used in the Parallax Component Solver.

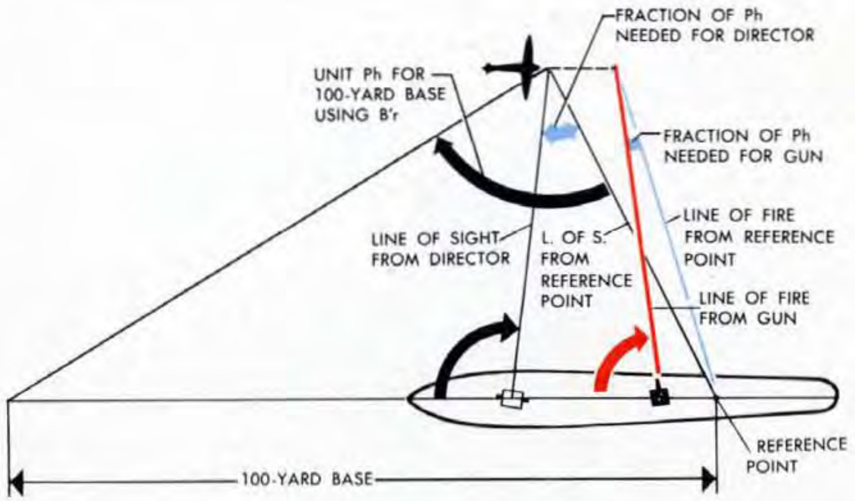


Multi - Director Ships

On Multi-Director ships, two complete sets of Parallax Corrections would be required to make accurate corrections to both the guns and the Directors.

A set of corrections based on *B′gr* would be needed to make the Line of Fire from each gun converge with the Line of Fire from the Reference Point. A set of corrections based on *B′r* would be needed to make the Line of Sight from each Director converge with the Line of Sight from the Reference Point.

Since the error involved is small, the Computer Mark 1 computes only one set of corrections for a 100-yard base, and uses it for both the Directors and the guns.

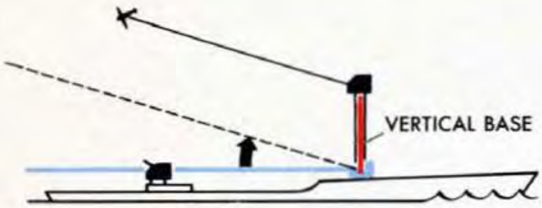


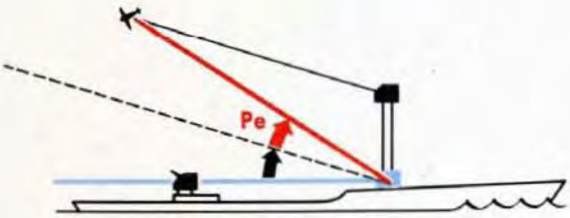
On Multi-Director ships, the guns are usually placed between the Directors; therefore the instrument farthest from the Reference Point is usually a Director rather than a gun.

Since the largest fraction of each Parallax Correction will be used by the instrument farthest from the Reference Point, Parallax Corrections based on Director Train, *B′r*, are computed on Multi-Director ships and used for both Directors and guns.

The guns, being located nearer the Reference Point than the Directors, use smaller fractions of these Parallax Corrections. The errors in the smaller corrections are correspondingly smaller; therefore the Parallax Corrections based on *B′r* are sufficiently accurate for use at the guns.

ELEVATION PARALLAX CORRECTION, Pe

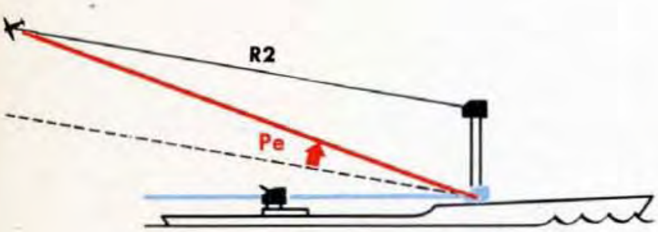




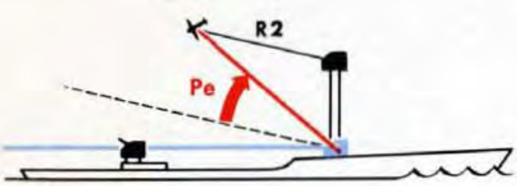
Elevation Parallax Correction, *Pe,* is the additional amount of Gun Elevation needed to compensate for the difference in height of the guns and the Director.

Pe is usually computed for a 30-foot vertical base.

The resulting correction is considered sufficiently accurate to compensate for the height of any Director above any gun and is *included in Gun Elevation Order, E′g, going to all the guns.*

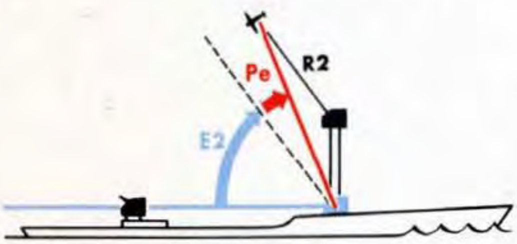


How R2 and E2 affect Pe

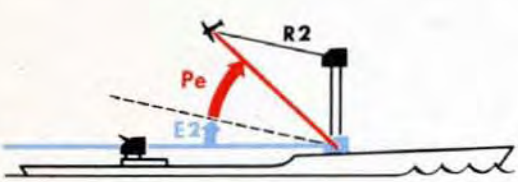


Pe is a function of Advance Range, *R2, and* Predicted Elevation, *E2.*

When *R2* is long, *Pe* is a small angle, and when *R2* is short, *Pe* is a *larger* angle.



Also, when *E2* is a large angle, *Pe* is a *small* angle. When *E2* is a small angle, *Pe* is a *larger* angle.

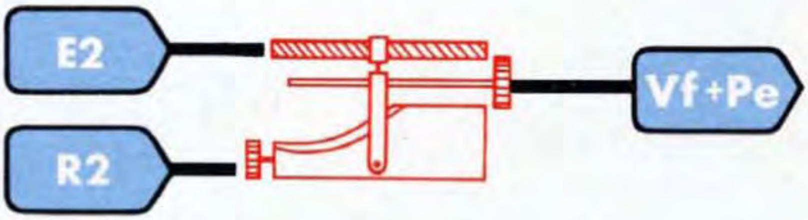


Notice that *Pe* is a function of *R2* and *E2* only. The values of Gun Train Order, *B′gr,* and Level, *L,* have no effect on the value of this correction.

The Vf+Pe ballistic computer

Pe is computed in the *Vf* + *Pe* Ballistic Computer in the Prediction Section.

E2 and *R2* are the inputs to the *Vf* + *Pe* Ballistic Computer.



R2 positions the ballistic cam. *E2* positions the lead screw that moves the cam follower along the cam.

Superelevation Correction, *Vf*, is the additional amount of Gun Elevation needed to compensate for the curve of the trajectory of the projectile.

Since *Vf* is also a function of *R2* and *E2*, one ballistic cam is cut to give the output of *Vf* + *Pe*. The value of *Pe* is therefore never on a shaft by itself, but is always included as part of the output of the *Vf* + *Pe* Ballistic Computer.

WHERE THE PARALLAX CORRECTIONS GO

Elevation Parallax Correction, *Pe*, becomes part of Gun Elevation Order, *E′g*, and is sent to all the guns.

Train Parallax Correction, *Ph*, positions a single-speed transmitter which sends *Ph* by synchro transmission to the guns and the Directors.

Elevation Parallax Correction, *Pv*, positions another single-speed transmitter which sends *Pv* to some guns, or to some Directors, or to some guns and some Directors, depending on the type of installation.

The **REFERENCE POINT or LINE** may be:

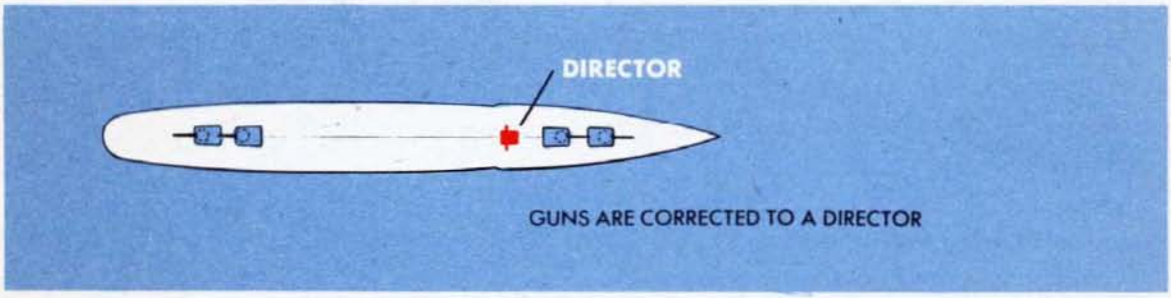
1 A Director

2 An imaginary point or line between two Directors

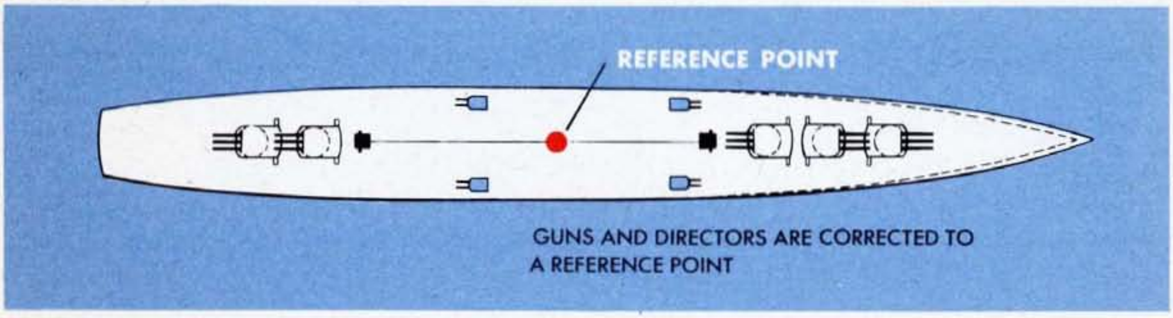
3 An imaginary line running through the Director

Here are some DIRECTOR and GUN

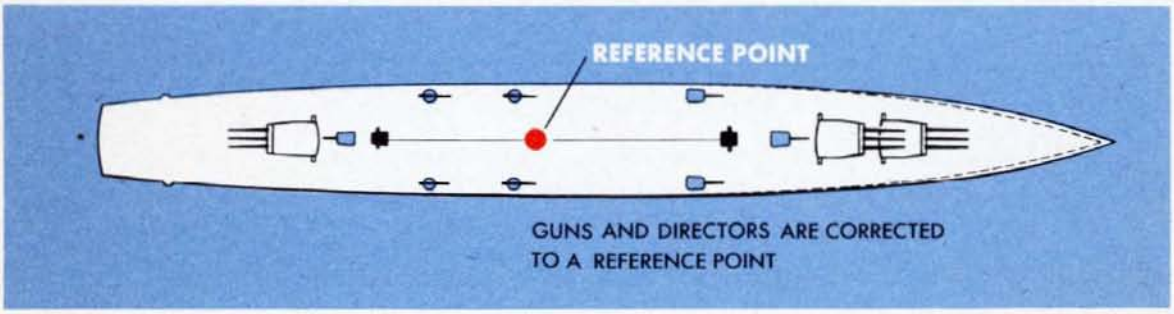
DESTROYER



LIGHT CRUISER



HEAVY CRUISER

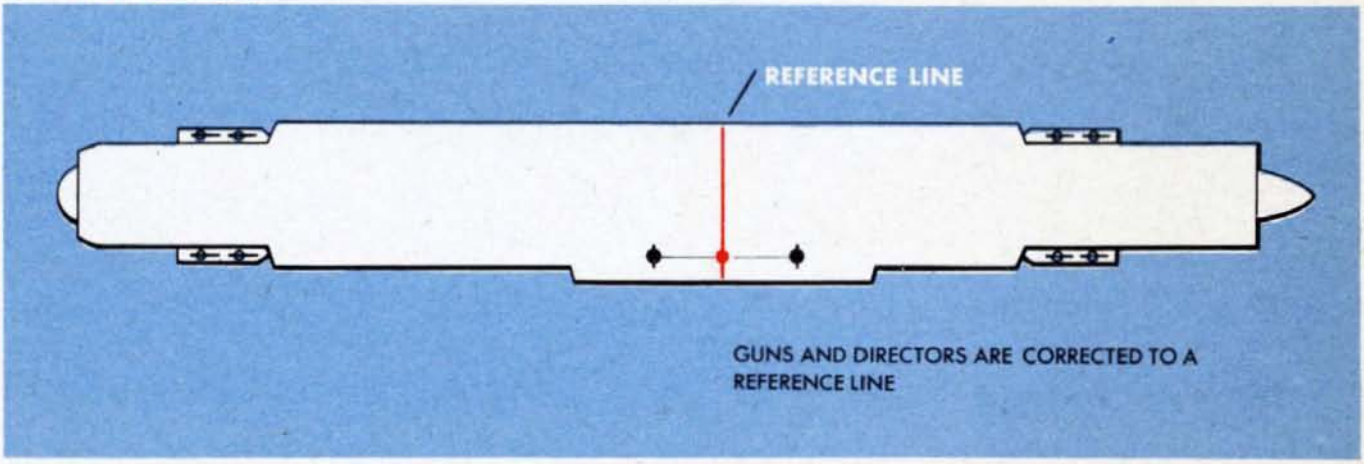


On a destroyer, the Director is the Reference Point.

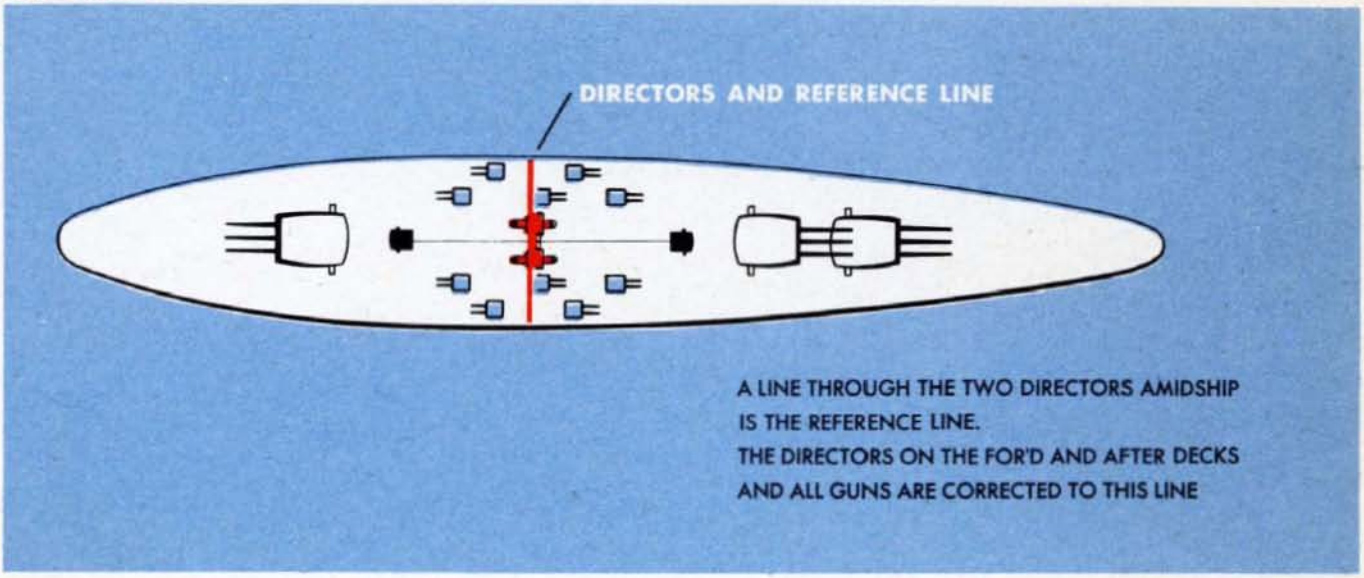
On other types of ships where guns and Directors are placed to starboard or port of an imaginary fore-aft line, corrections are made to a Reference *Line*. A Reference Line is a line running at right angles to the fore-aft axis and passing through a Reference Point or through one or two Directors.

arrangements for different types of ships

AIRCRAFT CARRIER



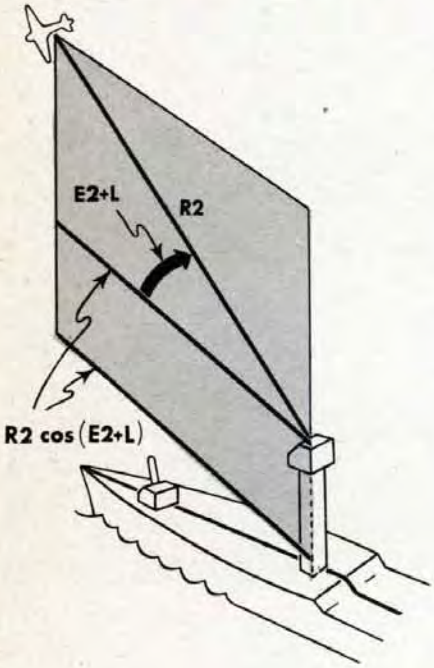
BATTLESHIP



Derivation of the parallax equations

This supplement is intended for those who wish to go further into the mathematical derivation of the equations for Train Parallax, *Ph,* and Elevation Parallax, *Pv.*

The equation for train parallax correction Ph



In the *Ph* derivation, Advance Range, *R2,* is projected onto the deck plane.

The first sketch shows that:

$$\text{Projected Advance Range} = R2 \cos (E2 + L)$$

The second sketch, where *bh* is the horizontal base between director and gun, shows that:

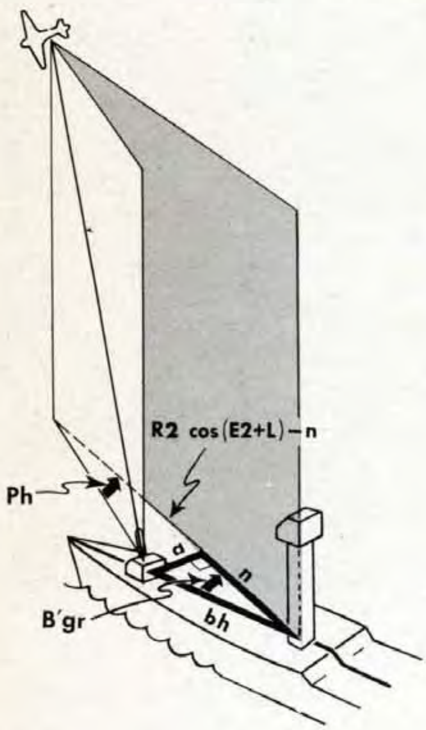
$$\sin B'gr = \frac{a}{bh}$$

$$a = bh \bullet \sin B'gr$$

Also, $\tan Ph = \dfrac{a}{R2 \cos (E2 + L) - n}$

Substituting for *a*

$$\tan Ph = \frac{bh \bullet \sin B'gr}{R2 \cos (E2 + L) - n}$$



Since n is small compared to $R2 \cos (E2 + L)$, it may be neglected.

Also, for small angles, $K \tan Ph = Ph$

Then $Ph = \dfrac{K \bullet bh \bullet \sin B'gr}{R2 \cos (E2 + L)}$

Since *Ph* is defined for a 100-yard base, and

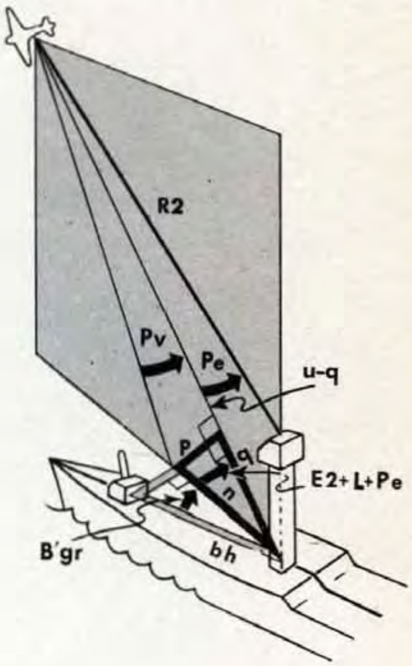
$$\frac{1}{\cos (E2 + L)} = \sec (E2 + L),$$

$$Ph = \frac{K \bullet 100 \bullet \sin B'gr \bullet \sec (E2 + L)}{R2}$$

The equation for elevation parallax correction Pv

In the vertical plane through the director,

$$\tan Pv = \frac{p}{u-q} \qquad (1)$$



Also, $\frac{p}{n} = \sin (E2 + L + Pe)$

or, $p = n \sin (E2 + L + Pe)$

Substituting this value for p in equation (1)

$$\tan Pv = \frac{n \sin (E2 + L + Pe)}{u-q} \qquad (2)$$

In the deck plane,

$$\frac{n}{bh} = \cos B'gr \qquad n = bh \cdot \cos B'gr$$

Substituting this value for n in equation (2)

$$\tan Pv = \frac{bh \cdot \cos B'gr \cdot \sin (E2 + L + Pe)}{u-q}$$

Since Pe is small compared to $(E2 + L)$, it may be disregarded in the equation.

The term $u-q$ is assumed equal to $R2$, since the resultant small error may be neglected.

Also, for small angles, $K \cdot \tan Pv = Pv$.

Then, by elimination and substitution,

$$Pv = \frac{K \cdot bh \cdot \cos B'gr \cdot \sin (E2 + L)}{R2}$$

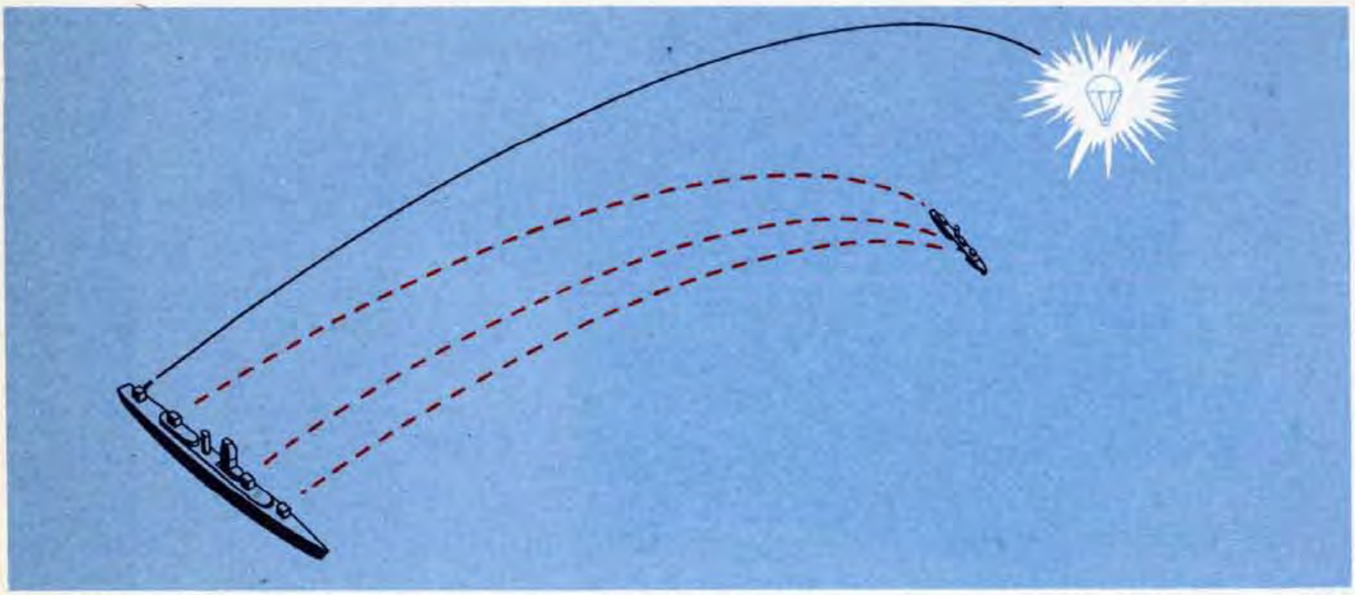
Since Pv is defined for a 100-yard base,

$$Pv = \frac{K \cdot 100 \cdot \cos B'gr \cdot \sin (E2 + L)}{R2}$$

Summary of the approximations and assumptions

1. Unlike Elevation and Bearing, Range is not corrected to compensate for the separation of the guns and Directors.
2. Director Elevation, *Eb*, does not receive *Pv* except on certain types of aircraft carriers where the distance between the Directors is long.
3. All Directors are assumed to be 30 feet higher than the guns.
4. All guns are assumed to be on the center line, the fore and aft axis of the ship. There is no correction for Parallax due to displacement of the guns from this center line.

The STAR SHELL COMPUTER MARK 1



The Star Shell Computer Mark 1 is an instrument which computes and transmits gun and fuze setting orders for a gun firing star shells.

A star shell is a projectile containing, instead of the usual explosive charge, a flare attached to a parachute. When the shell bursts, the flare is set on fire and burns for approximately one minute as it floats down. The flare itself is called a "star."

Star shells are fired at night, usually to illuminate surface targets.

The Star Shell Computer is designed to control only one kind of star shell fire: FIRE TO ILLUMINATE A SPECIFIC TARGET WHICH HAS ALREADY BEEN DETECTED AND FOR WHICH GUN ORDERS ARE BEING COMPUTED BY THE COMPUTER MARK 1. While the Computer Mark 1 computes gun orders to HIT a given target, the Star Shell Computer takes those gun orders and uses them to calculate another set of gun orders to ILLUMINATE THAT SAME TARGET.

Star shells are also used to SEARCH an area for a possible target. For this purpose a *Star Shell Computer is not needed*. The guns firing star shells can be pointed and the fuzes timed according to ship's doctrine.

Often star shell fire from more than one gun is desirable for a search.

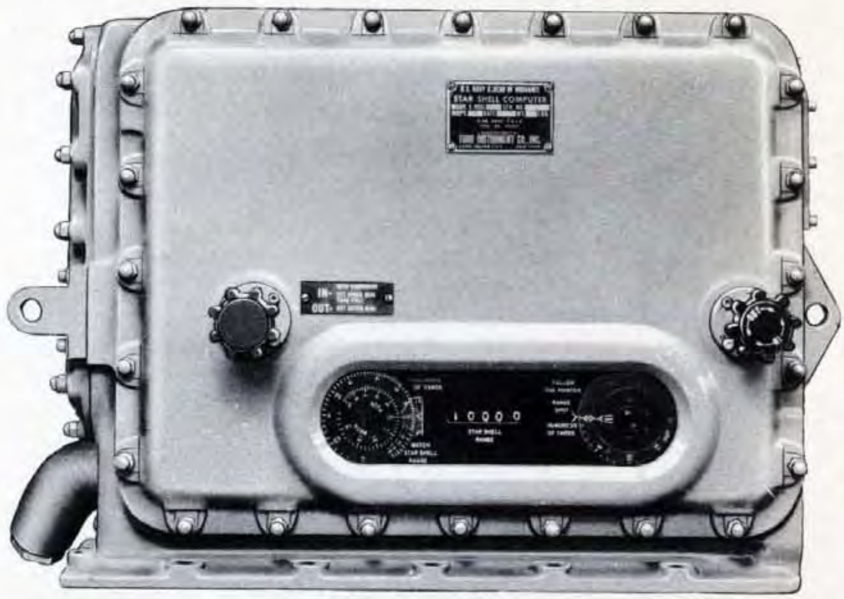
The star must form high enough above the water to allow time for the flare to burn out as it floats down. The Star Shell Computer is designed to compute a Fuze time and a Gun Elevation Order which will place the star 1000 yards beyond and 1500 feet above the moving Target, and a Gun Train Order which will place the star directly behind the Target after the star is half burned.

NOTE:
The Star Shell Gun Order Transmitters are 6DG's. The number and type of synchro-receiver installations which these transmitters can safely and accurately control at one time are limited. If it is desired to control more than one mount, the particular installation should first be investigated to determine the maximum practical load.

The Star Shell Computer computes three quantities:

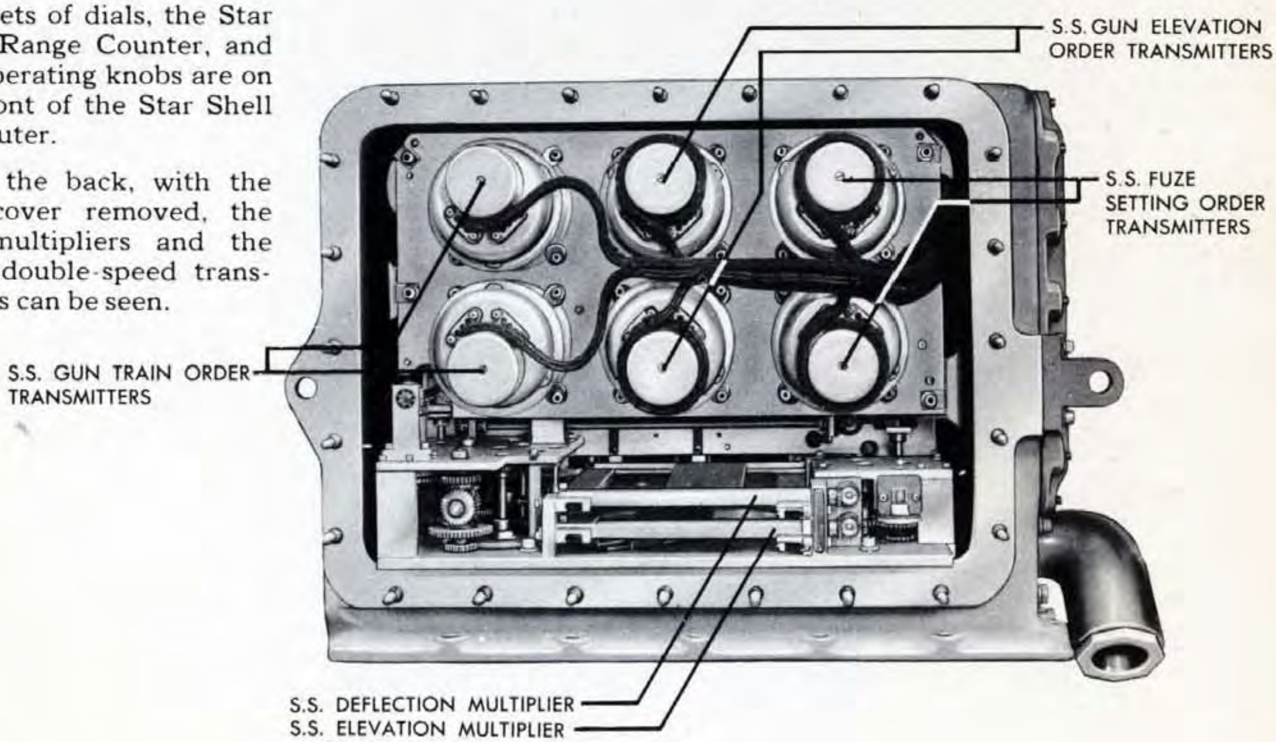
Star Shell Fuze Setting Order, *Fn*
Star Shell Gun Train Order, *B′grjn*
Star Shell Gun Elevation Order, *E′gjn*

The mechanism used to compute these quantities and transmit them to the gun firing the star shells includes two sets of special dials, two multipliers, three double-speed synchro transmitters, and a single-speed receiver. This mechanism is enclosed in a case on top of the Computer Mark 1.



Two sets of dials, the Star Shell Range Counter, and two operating knobs are on the front of the Star Shell Computer.

From the back, with the rear cover removed, the two multipliers and the three double-speed transmitters can be seen.



Star Shell RANGE

Here are the controls on the Star Shell Computer Mark 1.

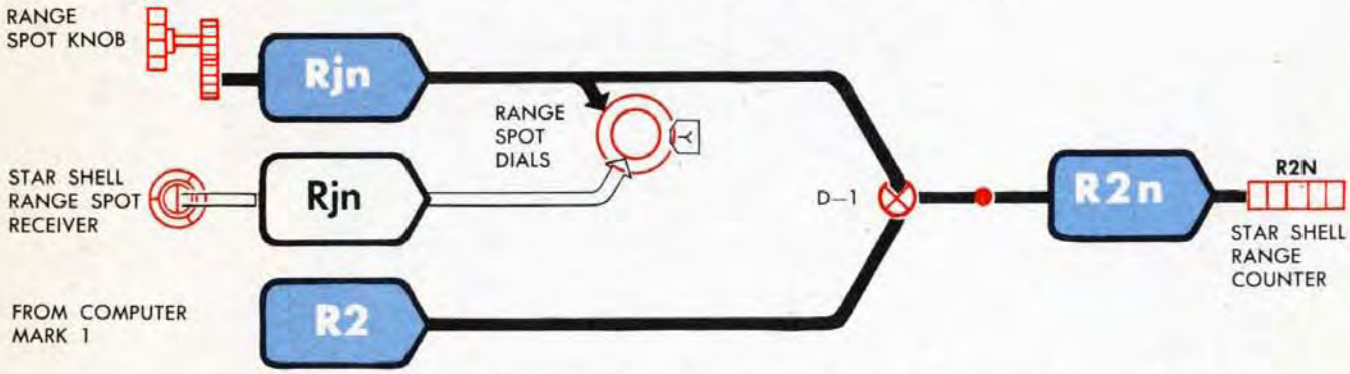
Star Shell Range, $R2n$, is the range to the point at which the star shell bursts, usually about 1000 yards beyond the Target. $R2n$ consists of Advance Range, $R2$, plus Star Shell Range Spot, Rjn, plus 1000 yards.

$$R2n = R2 + Rjn + 1000$$

Advance Range, $R2$, is received by shaft from the Computer Mark 1.

Star Shell Range Spot, Rjn, is a hand input based on information received by synchro transmission. The value of Rjn is sent by synchro transmission from the Star Shell Spot Transmitter to a synchro motor and dial in the Star Shell Computer. The value of Rjn is put into the Star Shell Computer mechanisms by hand by turning the Range Spot Knob until the index on the Range Spot Ring Dial is matched with the pointer on the inner Receiver Dial.

Rjn is added to $R2$ at differential D-1.

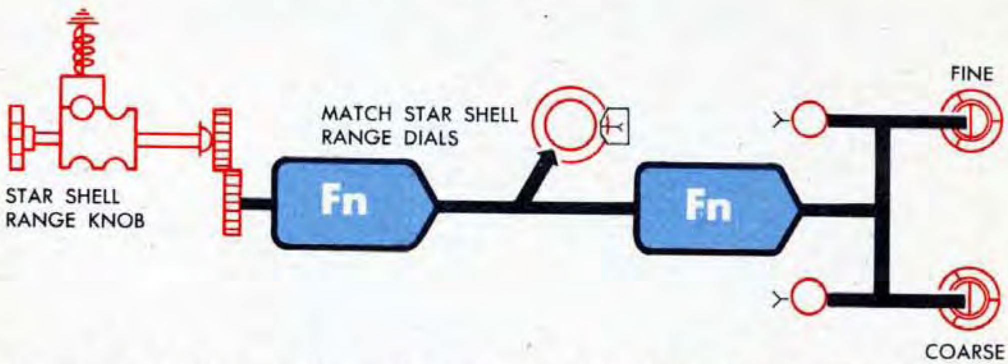


The additional 1000 yards is introduced at an offset clamp on the line to the $R2n$ Counter. This clamp is adjusted to make the $R2n$ Counter read 1000 yards more than the $R2$ Counters in the Computer Mark 1 when Rjn is zero.

Star Shell FUZE SETTING ORDER

Star Shell Fuze Setting Order is a function of Star Shell Range *R2n*. When Range increases, Fuze Time increases, not only to make up for the longer Range, but also to take account of the declining velocity and the higher trajectory of the projectile.

The Fuze line is connected to the *inner dial* of the Match Star Shell Range Dials. Matching this inner dial reading with the Star Shell Range Counter reading puts the correct value of *Fn* into the Star Shell Computer. The inner dial is positioned by the Star Shell Range Knob in its IN position.

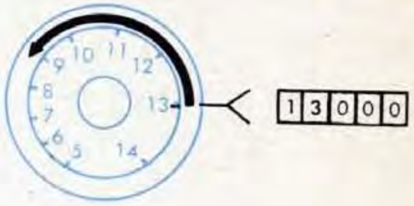


The Fuze Dial is graduated to compute a function of *R2n*. The graduations are unequally spaced so that THE DIAL ITSELF TAKES THE PLACE OF A COMPUTING CAM.

Here the dial has been turned from 5000 yards to 9000 yards to match the Range Counter.

Here it has been turned from 9000 yards to 13,000 yards to match the Range Counter.

ALTHOUGH THE CHANGE WAS 4000 YARDS IN EACH CASE, THE AMOUNT OF ROTATION WAS GREATER FOR THE SECOND 4000 YARDS THAN IT WAS FOR THE FIRST 4000 YARDS.

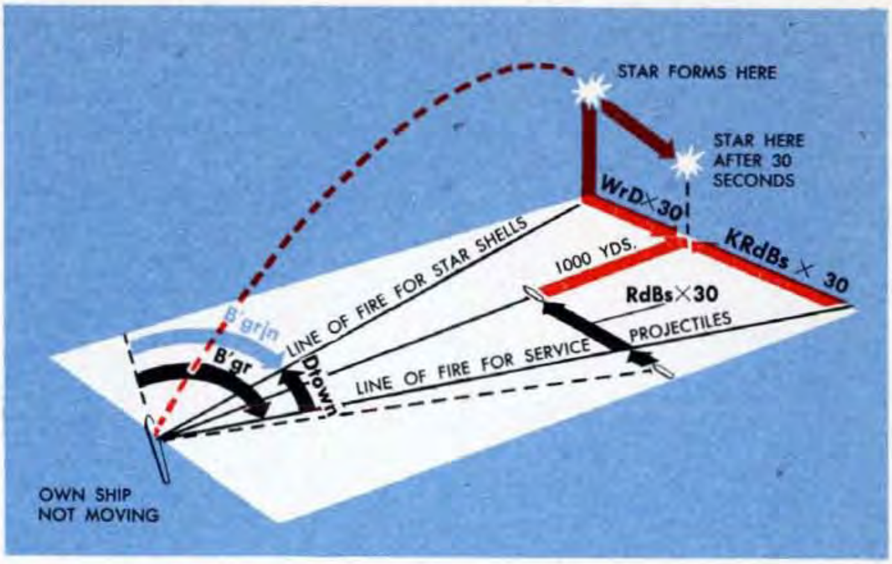


When the *inner dial* is turned to match the Range Counter, the amount of rotation of the line is a *function* of the yards of Star Shell Range, *R2n*, and represents Star Shell Fuze Setting Order, *Fn*.

The computed value of *Fn* positions the Fuze Setting Order Transmitter.

The proper Star Shell Fuze Dial must be installed for the type of star shell being used. The mechanical fuze star shell requires the fuze dial marked "Mech. Fuze." The powder fuze star shell requires the fuze dial marked "Pwdr. Fuze."

Star Shell GUN TRAIN ORDER



The star from a star shell should form *1000 yards beyond* the Target, and should be in a *direct line* with the Ship and Target after it has burned *30 seconds,* which is half the life of the star.

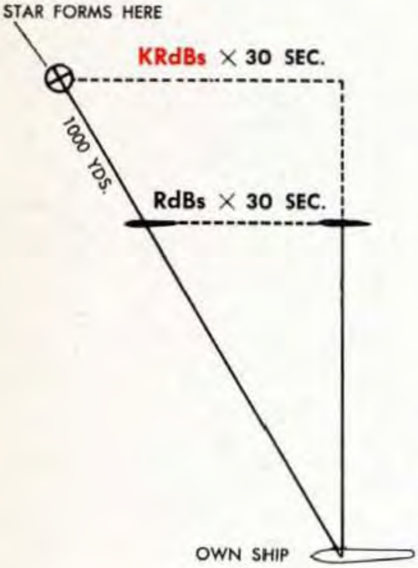
The Gun Train Order, *B′gr,* computed by the Computer Mark 1, is such that service projectiles will *hit the Target.*

The Computed Star Shell Gun Train Order, *B′grn,* consists of *B′gr* plus a train correction to take account of both deflection of Ship and Target during the 30 seconds, and deflection of the star due to wind during the 30 seconds.

This train correction is called *Dtown.* $B'grn = B'gr + Dtown$

Dtown is an angular correction computed by the equation:

$$\frac{\text{linear rate} \times \text{time}}{\textit{range}} = \text{angular change}$$



The RATE in this equation is $KRdBs + WrD$, the sum of Ship, Target, and Wind motion horizontally across the Line of Sight.

As the diagram at the left indicates, star shell deflection due to *RdBs* is always greater than *RdBs* from the Computer Mark 1. The gearing carrying *RdBs* to the Star Shell Computer puts in a constant *K* which approximates this difference and produces *KRdBs.* Wind deflection, *WrD,* is added to obtain $KRdBs + WrD$, the total deflection rate.

The TIME in the equation is a constant, *K*. Its value is 30 seconds because Own Ship, Target, and the star should line up after the star has been burning 30 seconds.

The RANGE in the equation is Star Shell Range, *R2n.*

The equation for *Dtown* is therefore:

$$\frac{(KRdBs + WrD) \times K}{R2n} = Dtown$$

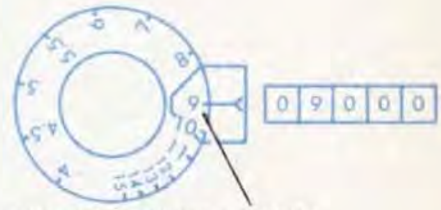
The equation for *Dtown* is solved by a dial and a screw-type multiplier.

The mechanism first computes the term $\frac{K}{R2n}$. This value is called *jDwn*.

The equation for *Dtown* can now be written:

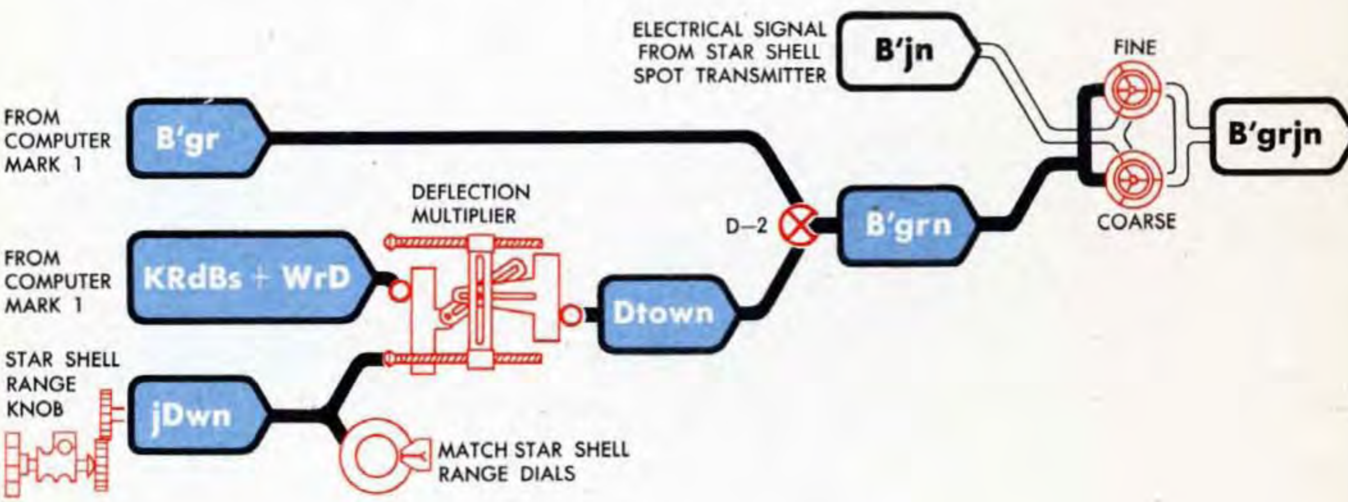
$$Dtown = jDwn \times (KRdBs + WrD)$$

jDwn is computed from *R2n* by the unequally spaced graduations on the ring dial of the Match Star Shell Range Dials. The ring dial acts as a computing cam just as the inner dial did in the Fuze Setting Order computation. The ring dial reading is matched to the Star Shell Range Counter reading by turning the Range Knob in its OUT position. This sets *jDwn* into the Deflection Multiplier.



RING DIAL MATCHED TO COUNTER PUTS jDwn INTO MECHANISM

The Deflection Multiplier is a screw-type multiplier which multiplies *jDwn* by *KRdBs* + *WrD*. *KRdBs* + *WrD* positions the rack; *jDwn* positions the lead screw. The output is *Dtown*.

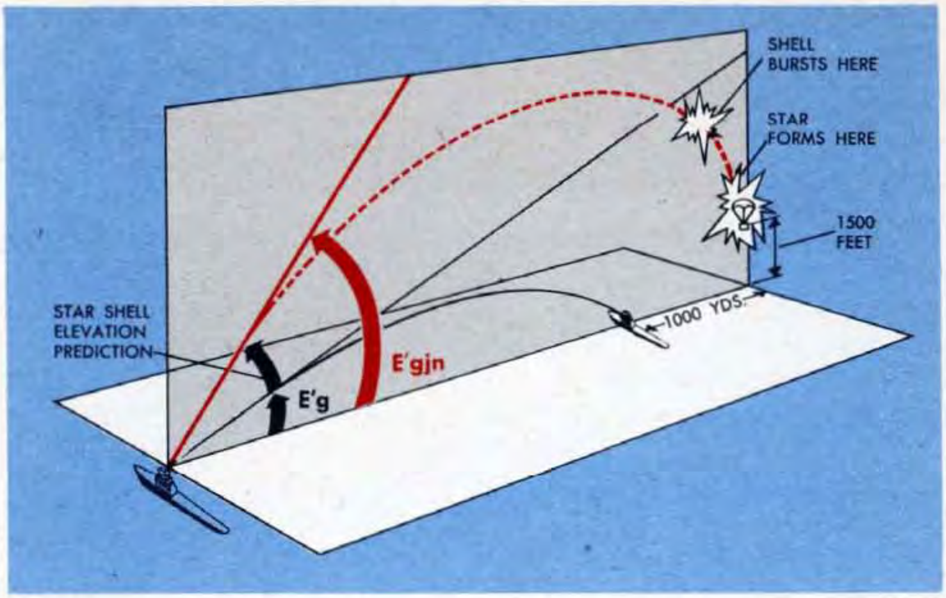


Computed Star Shell Gun Train Order, *B'grn*, is obtained by adding *Dtown* to Gun Train Order, *B'gr*, at differential D-2. In other words, the computation from Computer Mark 1 needed to hit the Target, and the correction needed to put the star, at half its life, in line with the Target, are combined to give Computed Star Shell Gun Train Order, *B'grn*.

B'grn drives a coarse and fine synchro differential generator in the Gun Train Order Transmitter. It is here that a further correction, Star Shell Deflection Spot, *B'jn*, is added electrically whenever needed. *B'jn* comes in electrically from the Star Shell Spot Transmitter in the Director.

The final output to the star shell gun is called Star Shell Gun Train Order, *B'grjn*.

Star Shell GUN ELEVATION ORDER



The Star Shell Elevation prediction must do more than simply correct Gun Elevation Order, $E'g$, from the Computer Mark 1, for the additional 1500 feet height of the star and the 1000 yards' additional range. It must include a correction for the fall of the star during the time interval between the burst of the shell and opening of the parachute, so that the star will *form* at an altitude of 1500 feet.

If the Star Shell Gun Elevation should be a *little* too low at the longer ranges, the star will explode just high enough to light up the surface for a few seconds before sputtering into the water.

NOTE:
The Star Shell Fuze Setting Order must also be highly accurate, for the same reason. The Star Shell Gun Train Order, however, can put the star several hundred feet to one side of the ideal location without seriously interfering with illumination.

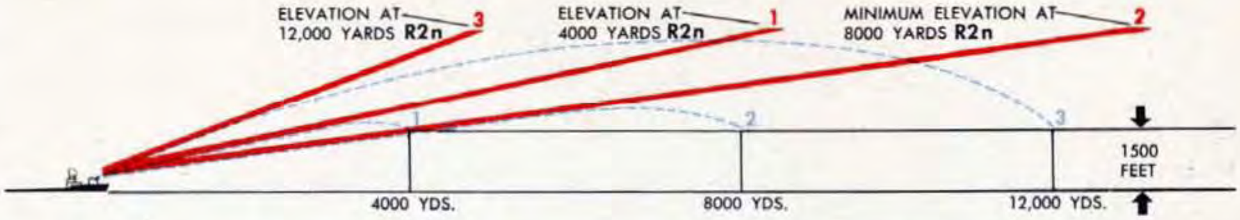
The equation for Star Shell Gun Elevation Order, $E'gjn$, has four terms.

The first term is $E'g + K$. The Star Shell Gun Elevation Order must put the star *beyond* and *above* the Target. This means that Star Shell Gun Elevation Order will always be larger than Gun Elevation Order, $E'g$, from the Computer Mark 1. K represents the minimum amount by which the Star Shell Gun Elevation Order always exceeds $E'g$.

$K_3 \cdot jDwn$ can be roughly pictured as a *negative* correction to Elevation, needed to keep the stars at the same height as range increases.

$K_1 \cdot Fn$ can be thought of as a *positive* correction to Elevation as range increases. It represents Superelevation. This term is further modified by Range Spot, Rjn.

$E'jn$ is the Star Shell Elevation Spot, which is added electrically at the Star Shell Gun Elevation Order Transmitter.



Why there are both a positive and a negative elevation correction

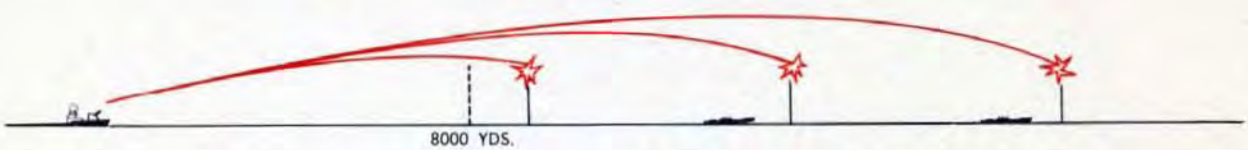
As Star Shell Range, *R2n*, increases from a minimum of 4000 yards up to about 8000 yards, the gun must be *depressed* to keep the star at 1500 feet altitude. Beyond that range the elevation must be *increased* to hold the 1500 feet altitude as the range increases, because of the increasingly curved trajectory of the shell.

To approximate this variation, two elevation corrections are computed. If 4000 yards is taken as a base, then, as Star Shell Range increases from 4000 yards, one of these corrections is a *negative* correction to that base and the other is a *positive* correction.

The negative correction predominates during the short ranges where the shells travel almost in a straight line. The positive correction predominates at the longer ranges.

$K_3 \cdot jDwn$

The negative correction decreases as Range increases. It happens to vary in about the same way as *jDwn;* therefore *jDwn* from the ring dial of the Match Star Shell Range Dials is multiplied through gearing by a constant, K_3, to bring it into scale with the other Elevation values. The product, $K_3 \cdot jDwn$, is used as the negative Elevation correction. This explains why Star Shell Deflection, *jDwn,* is an input to the Star Shell Gun Elevation Order network.



$K_1 \cdot Fn$

The *positive* Elevation correction is Superelevation, the *increase* in the Elevation Angle needed to compensate for the increased drop in the shell as Range increases.

Superelevation is about the same function of Star Shell Range as Star Shell Fuze Setting Order, *Fn.* The *Fn* Dial of the Star Shell Range Dials can therefore be used to compute this correction. The value on the Fuze line is multiplied by a constant, K_1, producing $K_1 \cdot Fn$. $K_1 \cdot Fn$ is used as the input to the lead screw of the Star Shell Elevation Multiplier, which produces the positive Elevation Correction, $K_1 \cdot Fn(K_2 + Rjn)$.

Summary of the Gun Elevation Computation

The equation for Star Shell Gun Elevation Order is:

$E'gjn = (E'g + K) + K_3 \cdot jDwn + K_1 Fn\,(K_2 + Rjn) + E'jn.$

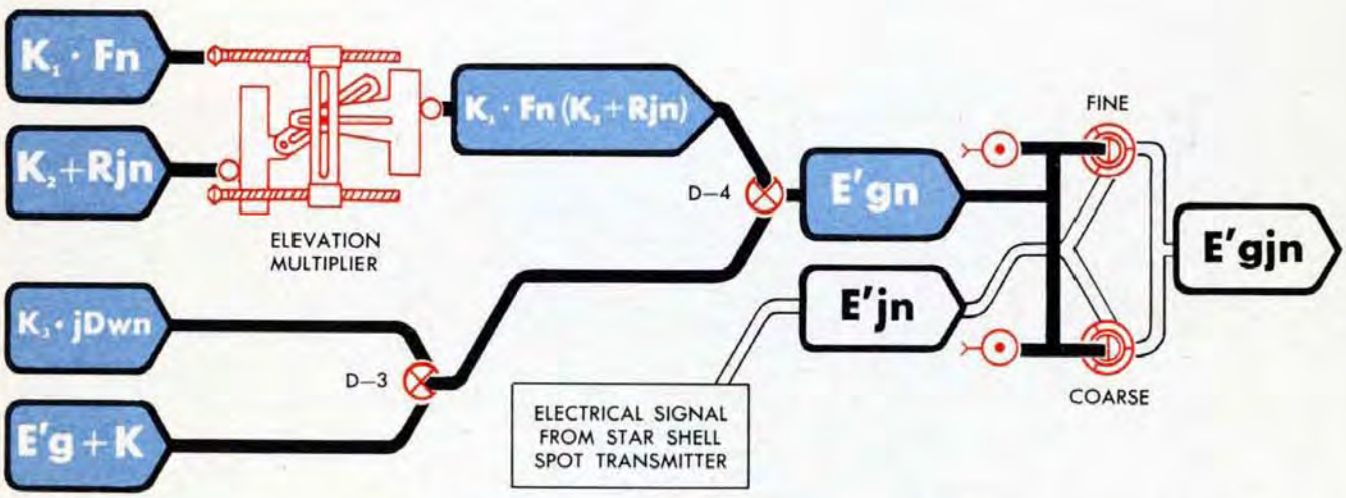
This equation is solved mechanically in four steps:

1 The Star Shell Elevation Multiplier multiplies $K_1 \cdot Fn$ by $K_2 + Rjn$.

2 $E'g + K$ from the Computer Mark 1 is added to $K_3 \cdot jDwn$ at differential D-3.

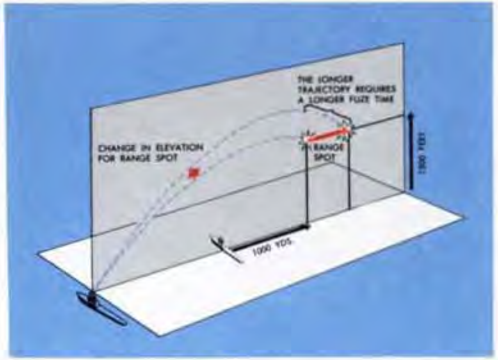
3 The output from D-3 is added to the multiplier output to obtain Computed Star Shell Elevation Order, *E′gn*. *E′gn* drives coarse and fine synchro differential generators in the Star Shell Gun Elevation Order Transmitter.

4 In the Star Shell Gun Elevation Order Transmitter, Star Shell Elevation Spot, *E′jn*, is added electrically to Computed Star Shell Gun Elevation Order, *E′gn*, to obtain Star Shell Gun Elevation Order, *E′gjn*, the electrical output to the gun.



Star Shell Deflection and Elevation Spots

Star Shell Deflection and Elevation Spots are added directly into the Star Shell Gun Train and Elevation Orders by means of differential generators. These generators add an electrical input to a mechanical input and transmit their sum electrically. Star Shell Deflection and Elevation Spots are sent down electrically from the Director to these differential transmitters and are there added to the Computed Star Shell Gun Train and Elevation Orders. A detailed description of differential generators can be found in OP 1140, in the chapter on Synchros.



Star Shell Range Spots

Range Spots present a different problem. If, for example, it is desired to put a star 1500 yards beyond the Target instead of 1000 yards at the same altitude, all the Star Shell Orders have to be modified.

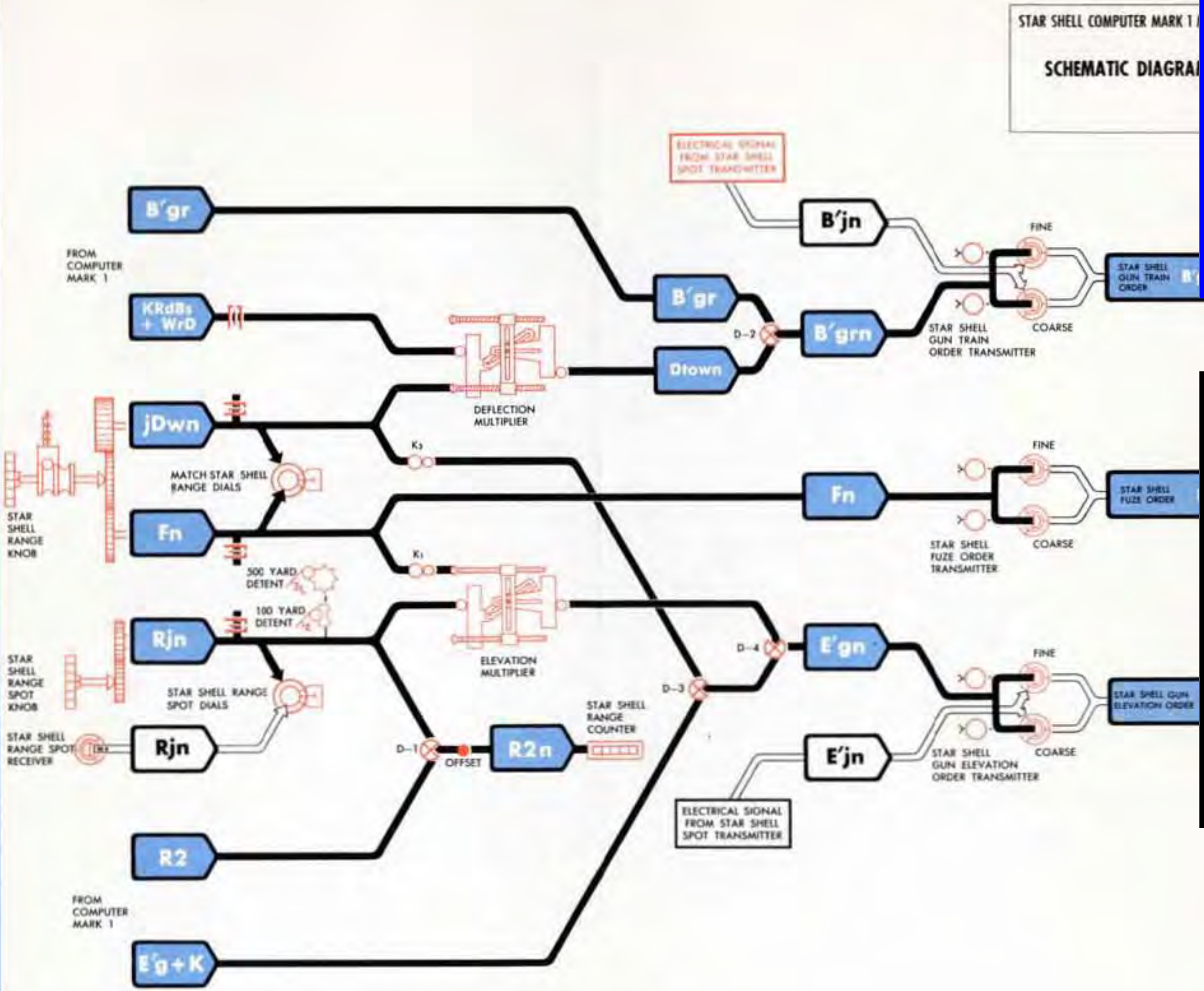
Fuze Time, *Fn*, must be longer, since the shell must travel farther. This change in Fuze Time is computed by matching the Fuze Dial to the new *R2n* value on the Star Shell Range Counter, which includes the spot. $R2n = R2 + 1000 + Rjn$.

A sufficiently accurate change in Star Shell Gun Train Order, *B′grjn*, results when the *jDwn* ring dial is matched with the new value on the Star Shell Range Counter. The change in Gun Train Order, which is not very important, has been omitted from the diagram above.

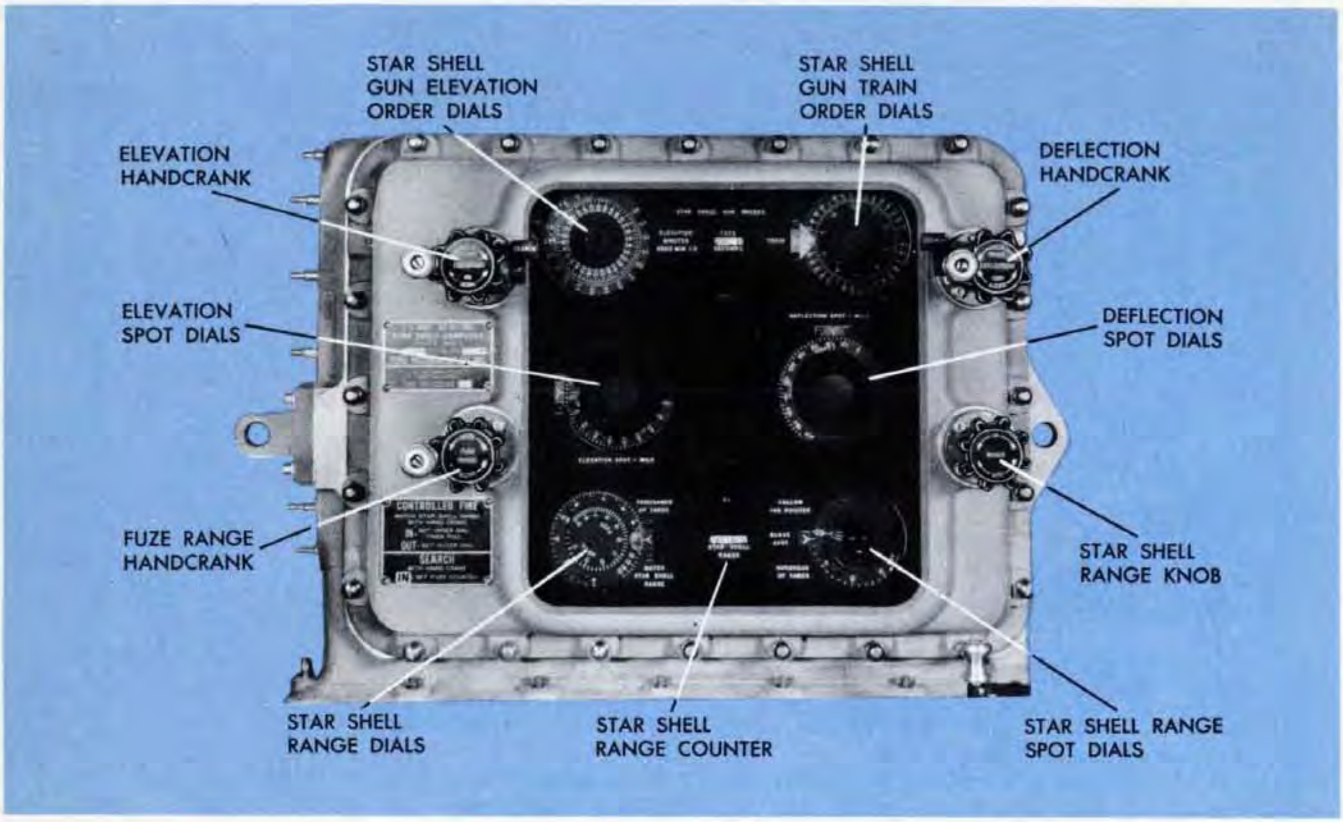
Star Shell Gun Elevation Order, *E′gjn*, must also be increased if a star is to burst an additional 500 yards beyond the Target and still form at 1500 feet altitude. Matching the *Fn* and *jDwn* Dials to the spotted value of Advance Range changes both the negative correction, $K_3 \cdot jDwn$, and the positive correction, $K_1 \cdot Fn$ in the Elevation computation. A third modification of the Elevation Order is needed to keep the star at 1500 feet. To approximate this modification, *Rjn* goes to the input rack of the Elevation Multiplier where K_1 is added as an offset. The multiplier output is $K_1 \cdot Fn\ (K_1 + Rjn)$.

STAR SHELL COMPUTER MARK 1

SCHEMATIC DIAGRAM



The STAR SHELL COMPUTER MARK 1 MOD 1



In order to implement the Star Shell Spot Transmitter Mark 1 and to provide for independent control of the Gun Order Transmitters, the Star Shell Computer Mark 1 Mod O was modified and was designated as Mod 1.

The computing mechanism in the Mod 1 is exactly like that in the Mod O, and, in general, operation of the Mod 1 is similar to that of the Mod O.

In the Mod 1, Elevation and Deflection Handcranks were added, each having two positions, SPOT and SEARCH. Elevation and Deflection Spot Dials were also added, and the window was enlarged to make the Star Shell Gun Elevation and Train Order Dials visible from the front.

With the handcranks in the SPOT position, Elevation and Deflection Spots may be introduced independently of the Star Shell Spot Transmitter Mark 1.

Elevation Spots are introduced through differential D-5 and Deflection Spots through differential D-6. The Elevation and Deflection Spot Dials indicate the respective quantities in mils. (The coarse Spot Dials remain within the graduation as long as the spots are within 200 mils.) Range Spots are introduced and indicated in this Mod as in Mod O. The Star Shell Spot Transmitter Mark 1 is still used for introducing normal Star Shell Spot Corrections.

For special types of control, other quantities may be set in by means of these spot handcranks.

In the SEARCH position, the handcranks control the Star Shell Gun Order Transmitters and Dials directly. Gun Train and Elevation Orders may be set at any desired values, independent of the rest of the mechanism.

The handcranks may be used in SEARCH position for controlling Search Fire. In this case the Gun Train Order is set in as desired, but the Elevation Order must be obtained from a previously prepared table. Such a table may be prepared by setting *E'g* on zero and reading *E'gjn* for values of *R2n* set into the Star Shell Computer. Star Shell Fuze Order is set in with the Fuze Range Handcrank in its IN position. Since the gun orders are not stabilized in this type of control, Selected Level Fire is necessary.

The Star Shell Transmitters were designed to control only a single gun. When it is desired to control a complete battery, the problem should be set up on a Computer Mark 1.

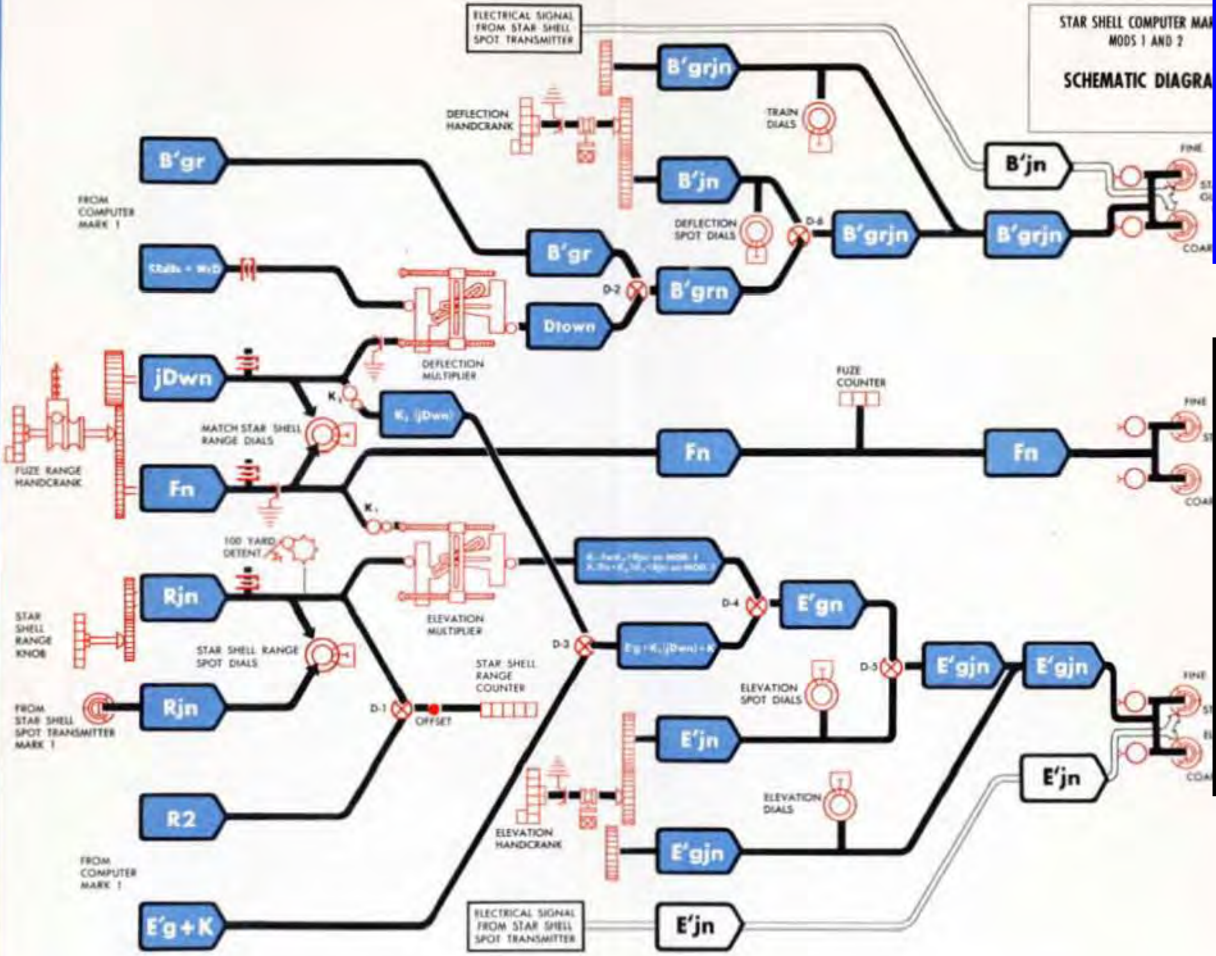
Controlling the fire of smoke projectiles

The design of the Mod 1 and the changes made in the Mod O by ORDALT 2117 permit the Star Shell Computer to be used for controlling the fire of smoke projectiles.

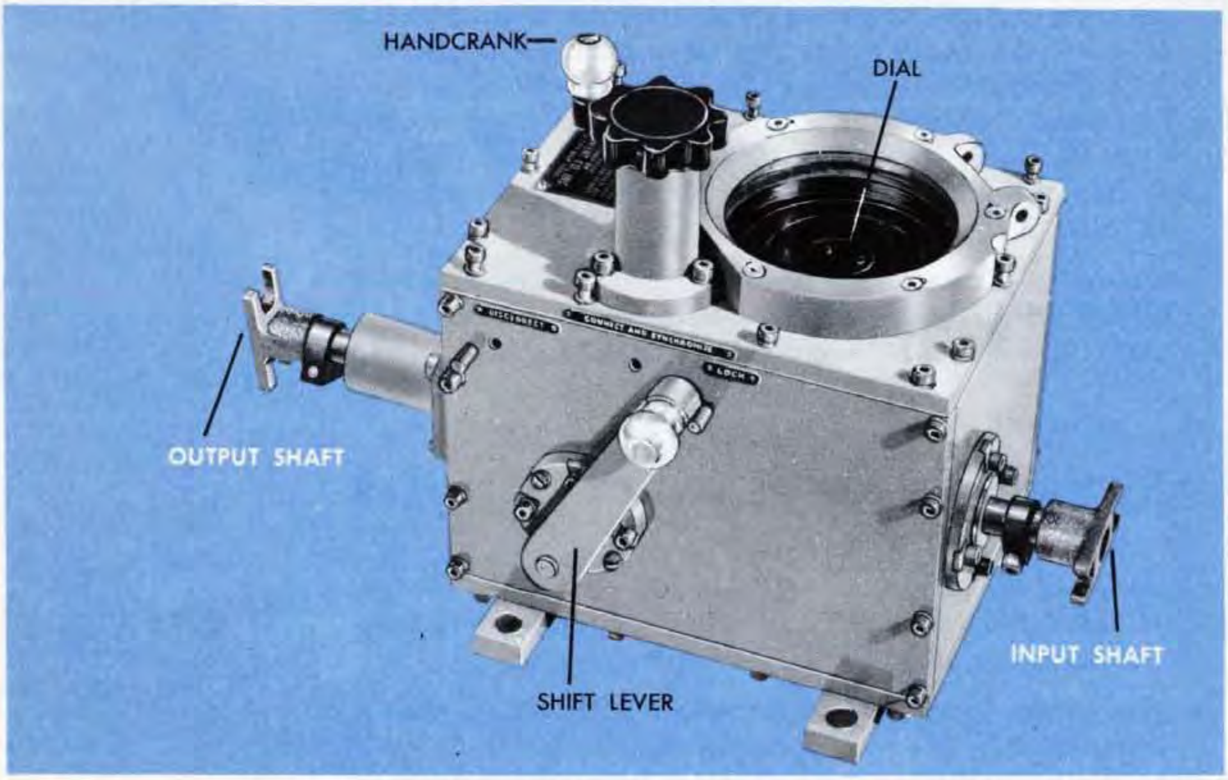
The Range Spot limit has been increased to IN 2857 in Mod 1 and is indicated by the red dot on the dial. To set up for control of smoke projectiles, Range Spot is set at IN 2857. This setting positions the Elevation Multiplier at zero, eliminating the effect of *Fn* on *E'gjn*. This places the burst about 2000 yards in front of the Target. Elevation Spots tabulated against *R2n* are used to introduce continuous corrections to place the burst from 25 to 50 feet above the water, instead of 1500 feet above the Target as computed by the Star Shell Computer. The Deflection Correction is the same as that for star shells, putting the smoke in line between Own Ship and Target 30 seconds after the burst.

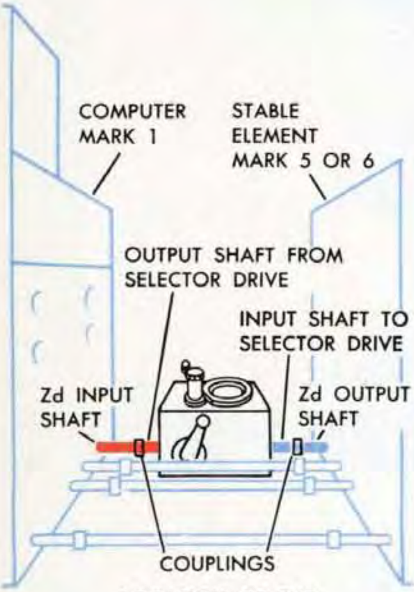
The STAR SHELL COMPUTER MARK 1 MOD 2

The Star Shell Computer Mark 1 Mod 2 is almost identical with the Mod 1, but is designed for the 5"/54 cal. guns and requires slightly different ballistic values. The *Fn* and *jDwn* Range Dials are calibrated slightly differently. There is also a difference in the output of the Elevation Multiplier in the Mod 2: An offset constant K_2 is added to *Fn* to make the multiplier output K_1 $(Fn + K_2)$ $(K_3 + Rjn)$. In the Mod 2, the Elevation Multiplier is at the zero position with the Range Spot set at IN 2700 yards.



The SELECTOR DRIVE MARK 1





LOCATION OF THE SELECTOR DRIVE

The Selector Drive is a mechanism used to disconnect, and to connect and synchronize, the Cross-level shaft line between the Stable Element Mark 5 or 6 and the Computer Mark 1. It also provides a means of putting a selected value of Cross-level, *Zd,* into the Computer. Usually this selected value is 2000 minutes.

The Selector Drive is located between the Computer Mark 1 and the Stable Element Mark 5 or 6, replacing the Cross-level shaft which normally connects these two instruments. Two shafts, an input shaft and an output shaft, project from opposite sides of the Selector Drive. The Selector Drive *input* shaft is coupled to the *Zd output* shaft from the Stable Element. The Selector Drive *output* shaft is coupled to the *Zd input* shaft to the Computer. The *Zd* line to the Computer may be disconnected inside the Selector Drive, and a selected value of *Zd* may be put into the Computer through the Selector Drive output shaft by turning the Selector Drive Handcrank.

The Selector Drive mechanism is contained in a metal box. On the front is a shift lever with three positions: DISCONNECT, CONNECT AND SYNCHRONIZE, and LOCK. On top of the box are a dial assembly and the handcrank. The handcrank and dials are used for synchronizing the *input* and *output* shafts.

Why a selector drive is needed

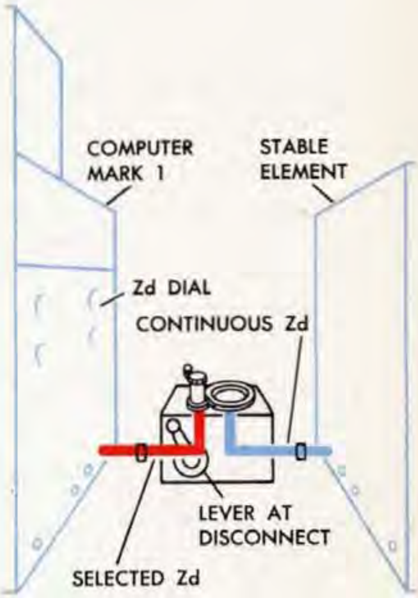
When the Director is searching for a target, the Stable Element must be operating in order to stabilize the Director sights and Range Finder. The Computer must be energized in order to supply *B'r* to the Stable Element. Since no other Computer outputs are required in this type of operation, needless wear on the Computer parts can be eliminated by setting the inputs of both *L* and *Zd* from the Stable Element at fixed values.

The type of Stable Element used on most ships permits the setting of *either* the Level *or* the Cross-level input to the Computer at a fixed value, but not both simultaneously. Installation of a Selector Drive Mark 1 on these ships makes it possible to set *both* the Level and the Cross-level inputs at fixed values at the same time. Level can be set at the Stable Element and Cross-level at the Selector Drive.

(Since the type of Stable Element used on destroyers of the DD409-420 class permits the setting of both the Level and Cross-level inputs to the Computer at fixed values, no Selector Drives are furnished for the Computers on these ships.)

Selected cross-level

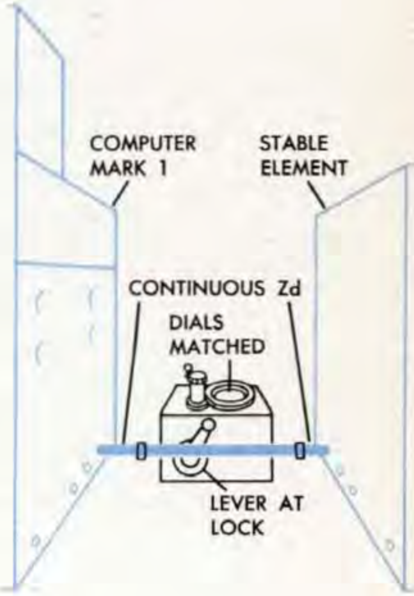
To set a selected value of Cross-level into the Computer when Level is being selected at the Stable Element, the Selector Drive shift lever is put in the DISCONNECT position. In DISCONNECT, *Zd* from the Stable Element does not drive the Computer but merely rotates the dials of the Selector Drive. A selected value of *Zd* is put into the Computer by turning the Selector Drive Handcrank until the required value is read on the *Zd* Dial on the rear of the Computer. This required value is usually zero, which is read as 2 000 minutes on the Computer *Zd* Dial.



Continuous cross-level

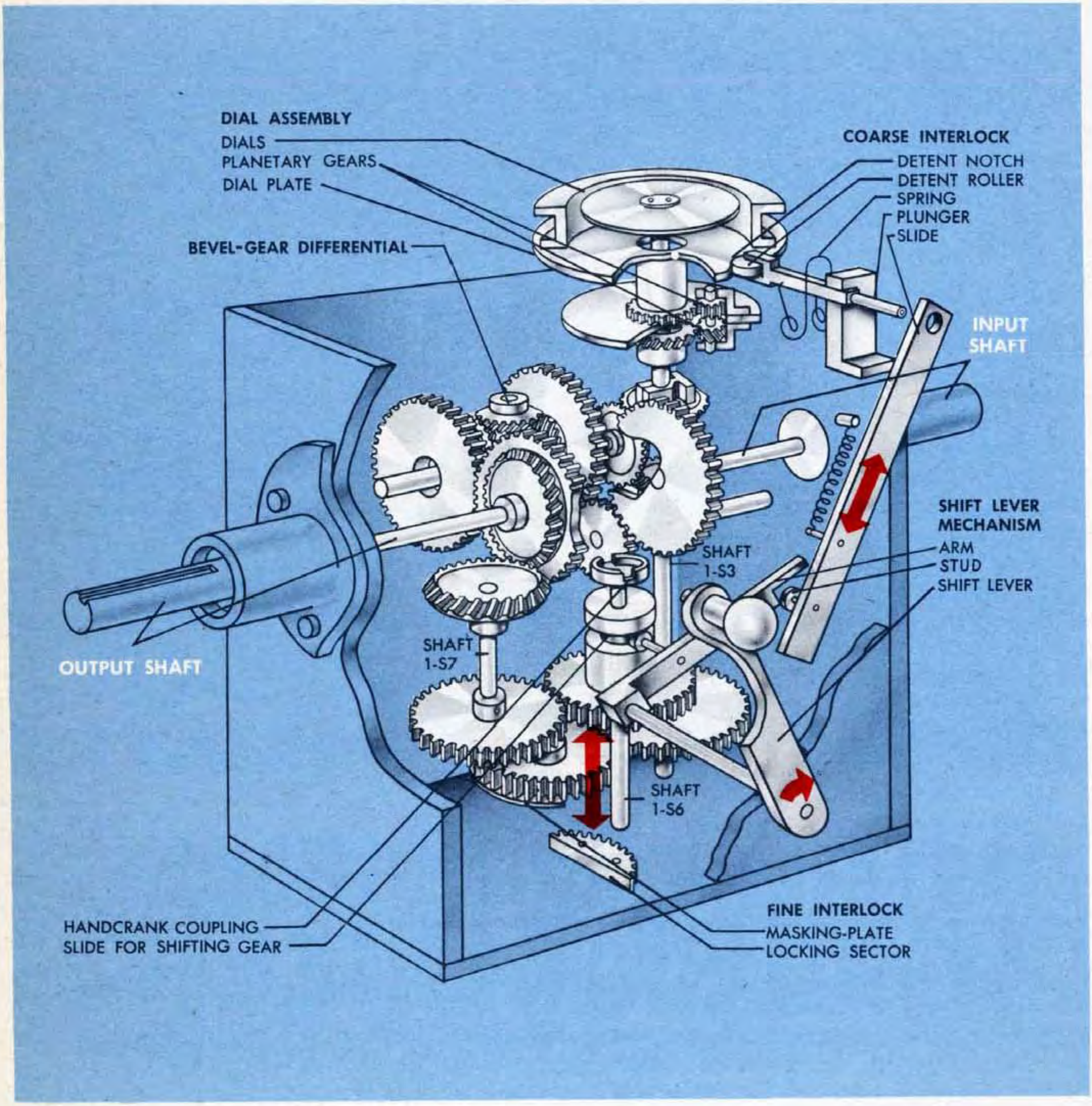
For Continuous Aim, continuous values of *Zd* are needed in the Computer. These continuous values are transmitted through the Selector Drive, which functions in Continuous Aim as a shaft between the Stable Element and the Computer.

To set the Selector Drive for transmitting continuous values of *Zd*, the shift lever is moved to the CONNECT AND SYNCHRONIZE position. The handcrank is turned until the indexes on both of the Selector Drive Dials are matched at the fixed index. This synchronizes the input and output shafts. The shift lever is then moved to the LOCK position. In the LOCK position the input and output shafts are *held in synchronism* and function as a direct drive between the Stable Element and the Computer.

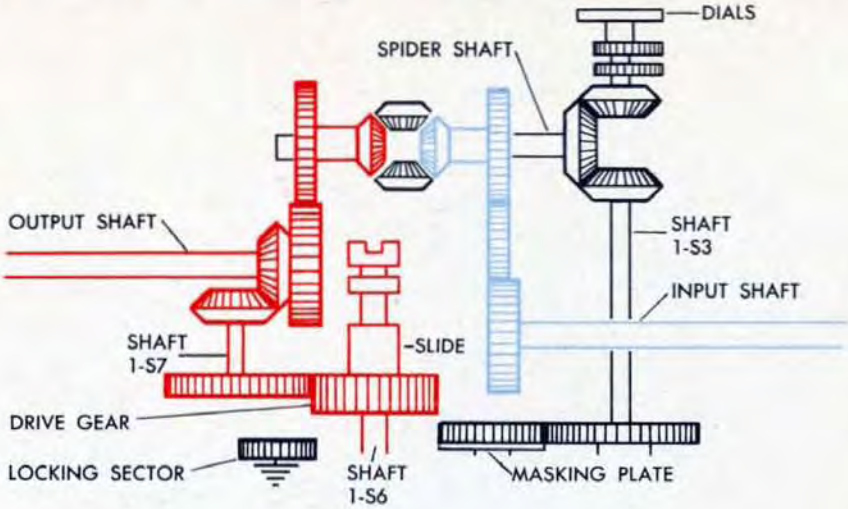


The SELECTOR DRIVE MECHANISM

The Selector Drive Mechanism consists of the input and output shafts, a bevel-gear differential, the handcrank assembly, the shift lever mechanism, the dial assembly, and a coarse and fine interlock.



The shaft lines



The input shaft from the Stable Element positions one side of the differential.

The output shaft is geared directly to the other side of the differential and to shaft 1-S7.

The spider of the differential is connected to the dials and to shaft 1-S3.

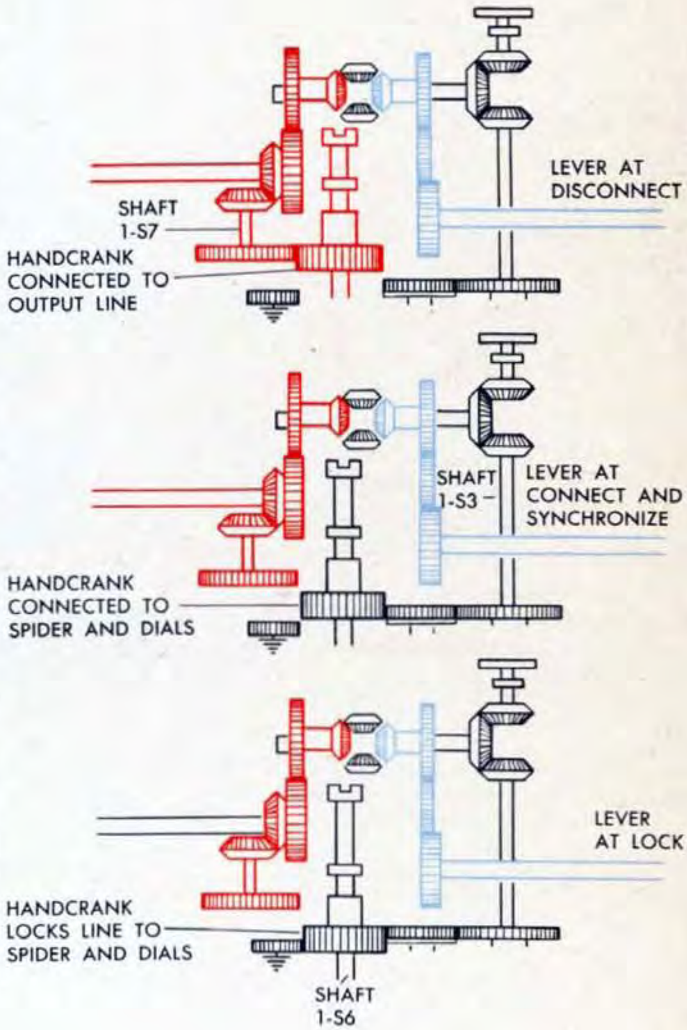
On shaft 1-S6 there is a slide carrying the drive gear. The slide permits the gear to be moved up and down along shaft 1-S6 by the shift lever.

The drive gear on shaft 1-S6 can be moved to any one of three positions by positioning the shift lever.

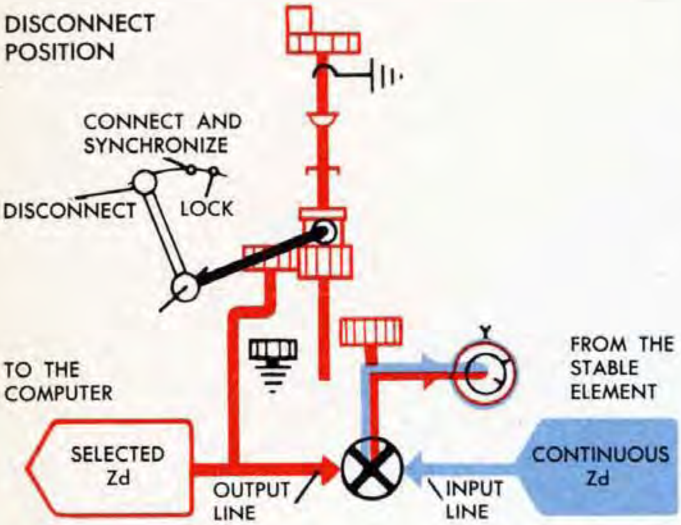
When the shift lever is in DISCONNECT position, the drive gear is in its highest position, meshing with the lower gear on shaft 1-S7. This connects the handcrank to the output shaft.

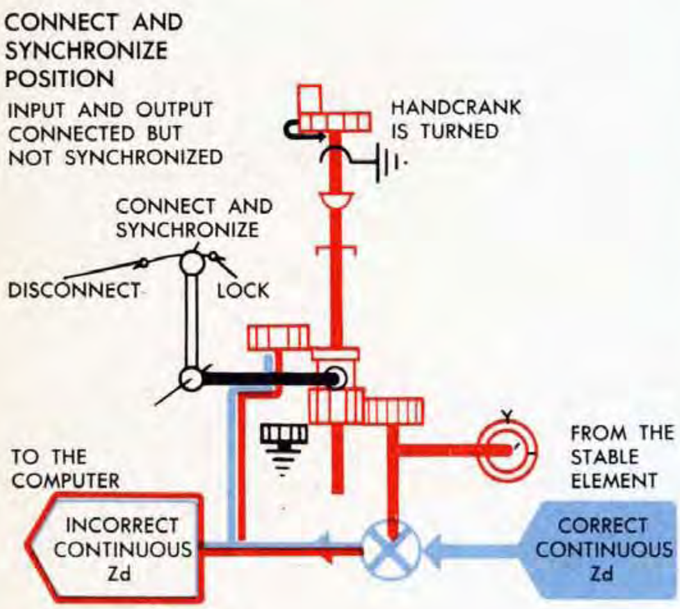
When the shift lever is in CONNECT AND SYNCHRONIZE position, the drive gear meshes with the masking-plate gear, which meshes with a gear on shaft 1-S3. Through these gears the handcrank is connected to the differential spider and the dials.

When the shift lever is in LOCK position, the drive gear is in its lowest position. It is still connected to the shaft line to the spider and dials, but now it also meshes with the fixed locking sector on the base plate of the Selector Drive. Since this locking sector is fixed, the drive gear in LOCK position locks shaft 1-S3, the differential spider, and the dials.



How the SELECTOR DRIVE works





The Selector Drive receives continuous input values of *Zd* from the Stable Element.

In the DISCONNECT position of the shift lever, the handcrank is connected to the output shaft line. The *Zd* values from the Stable Element position the input line and, following the line of least resistance, back out through the spider of the differential, turning the Selector Drive Dials. A selected value of *Zd* is set into the Computer by turning the handcrank to position the output shaft. The selected value also backs out through the spider and dials. The selected value of *Zd* is read on the *Zd* Dial at the rear of the Computer.

In the CONNECT AND SYNCHRONIZE position, the handcrank is connected to the spider of the differential and to the dials. The continuous *Zd* values from the Stable Element position the input line and the input side of the differential. The handcrank holding friction prevents these input values from backing out through the spider; therefore, they drive out through the output side of the differential and turn the output shaft. The input and output lines are now connected but the value of *Zd* in the Computer may not be the same as the value of *Zd* in the Stable Element.

To SYNCHRONIZE the input and output shaft lines

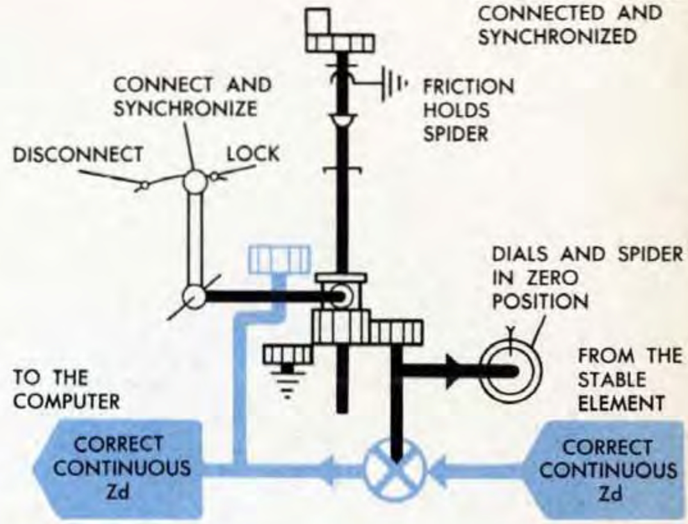
With the lever still at CONNECT AND SYNCHRONIZE position, the handcrank is turned, turning the differential spider until the spider is at its zero position. This handcrank input combines with the input from the Stable Element, and both drive out through the output side of the differential. As the handcrank is turned, the value of *Zd* on the output side of the differential approaches the value on the input shaft. When the differential spider reaches its zero position, the value on the output side of the differential equals the value driving through from the input side, and the input and output shafts are synchronized. The value of *Zd* in the Computer is equal to the value of *Zd* in the Stable Element.

Synchronism is complete when the spider has been turned to its zero position. The spider is in its zero position when the indexes on both dials are matched at the fixed index. The spider and dials are held stationary in this synchronized position by the holding friction on the handcrank. Continuous *correct* values of *Zd* now drive through the differential to the output shaft line. When the spider and dials are in their zero positions, the interlock mechanism is also in position to allow the shift lever to be moved to LOCK position.

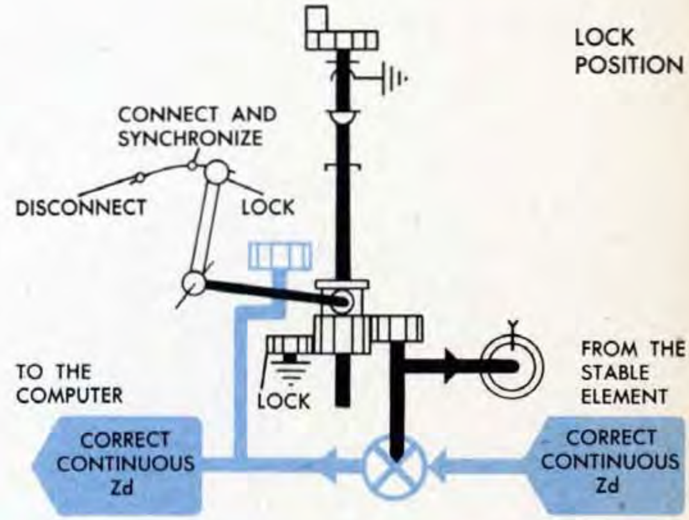
In LOCK position of the shift lever, the sector locks the shaft line to the spider and dials. The sides of the differential are held in synchronism, and correct continuous values of *Zd* from the Stable Element drive through the Selector Drive to the Computer. The mechanism now functions as a shaft carrying the varying *Zd* value from the Stable Element to the Computer. Turning the handcrank in the LOCK position will merely cause the friction drive to slip and will not throw the Computer and Stable Element out of synchronism.

CONNECT AND SYNCHRONIZE POSITION

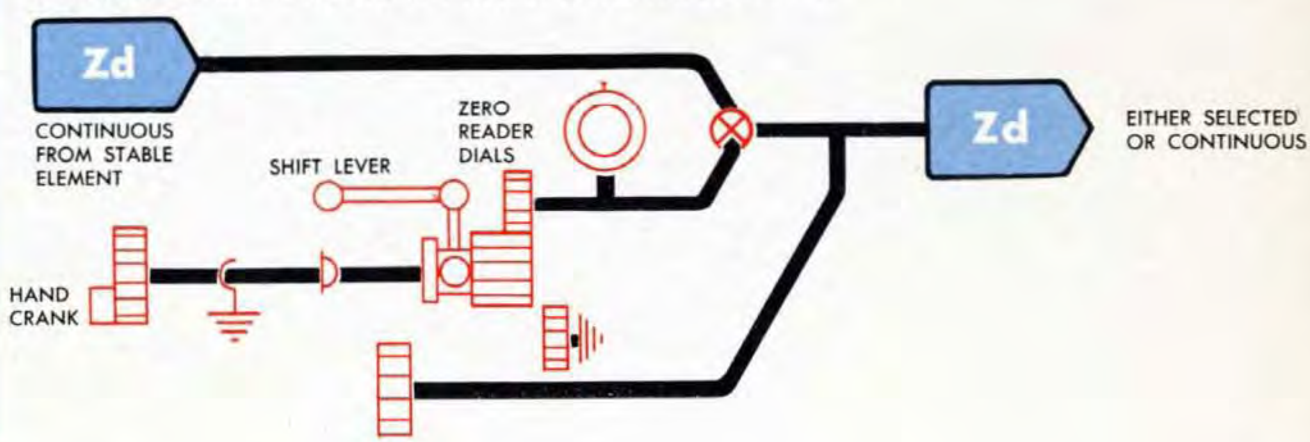
INPUT AND OUTPUT CONNECTED AND SYNCHRONIZED



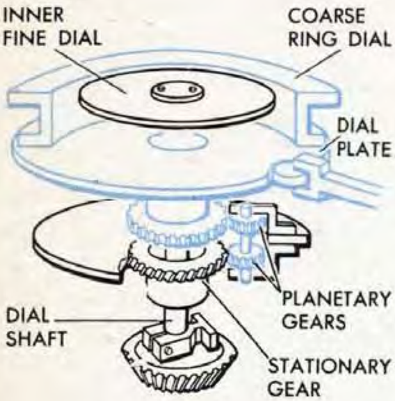
LOCK POSITION



THE SELECTOR DRIVE IS SHOWN THIS WAY IN THE MAJOR SCHEMATICS



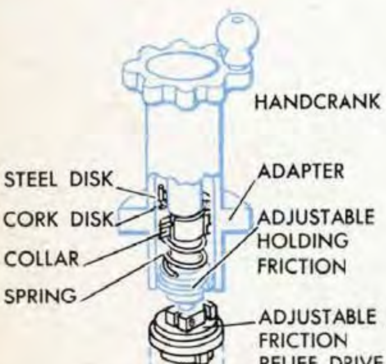
The dial assembly



PLANETARY DIALS

The inner fine dial and the disk carrying the planetary gears turn with the dial shaft. The planetary gears drive the coarse ring dial which is mounted on the dial plate. The planetary gearing is designed so that the ring dial makes one revolution for 18 revolutions of the inner dial.

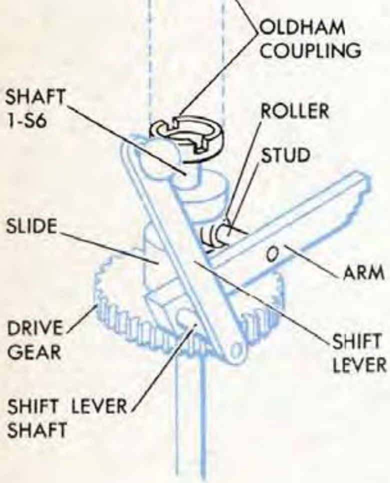
The handcrank assembly



HANDCRANK

The handcrank is a one-position handle. It has an adjustable holding friction inside the adapter and an adjustable friction relief drive. The handcrank is connected to shaft 1-S6 by an Oldham coupling. This coupling permits the top cover and handcrank to be removed without disturbing the shaft lines inside the Selector Drive.

The shift lever mechanism



SHIFT LEVER

The function of the shift lever mechanism is to move the drive gear from one position to another.

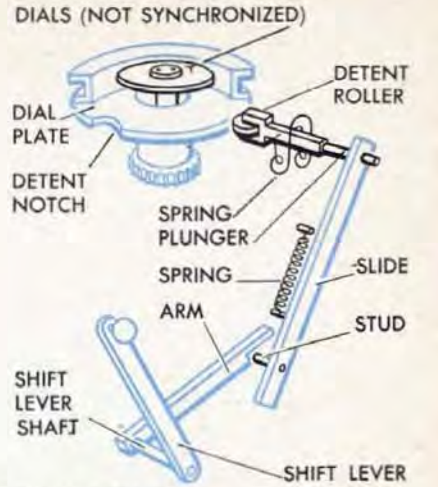
The grooved slide carrying the drive gear is keyed to shaft 1-S6. The slide and gear rotate with the shaft and may also move up and down on the shaft. An arm is pinned to the shift lever shaft. This arm has a stud on which is mounted a roller. This roller fits into a groove on the slide. As the shift lever is moved the arm and roller are rotated through an arc, raising or lowering the drive gear on the shaft. Moving the shift lever to any one of its three positions therefore also moves the drive gear to a corresponding position.

The coarse interlock

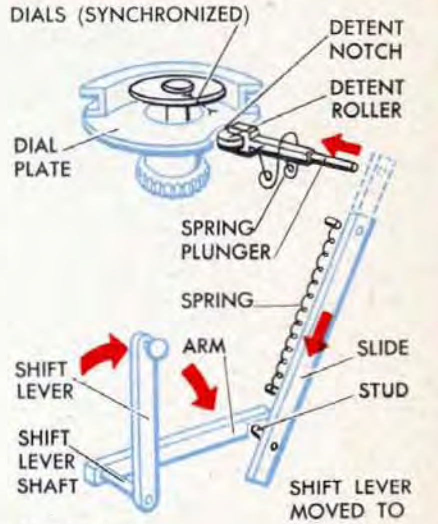
A coarse and fine interlock prevent the shift lever from being moved to the LOCK position when the input and output shafts are not synchronized. The coarse interlock is a linkage between the shift lever and the dials. It consists of an arm, a slide, and a plunger holding a detent roller. The arm is connected to the shift lever, at right angles to the lever.

When the shift lever is moved toward LOCK position, the end of the arm pushes against a stud on the end of the slide. The shift lever can move to the LOCK position only when the slide is free to move to its lower position. As long as the detent roller is out of the notch in the dial plate, the slide is held in its upper position by the plunger, which passes through a hole in the top of the slide. When the dials are not synchronized, therefore, the slide is held in its upper position, and the stud on the slide prevents the shift lever from moving to the LOCK position.

When the dials *are* synchronized at the fixed index, the notch in the dial plate lies opposite the detent roller. A spring pushes the detent roller into the notch. When the detent roller enters the notch the plunger is drawn out of the hole in the slide. The slide is free to move. As the shift lever is moved to LOCK position, the arm on the shift lever pushes against the stud and moves the slide to its lower position.



COARSE INTERLOCK IN CONNECT POSITION

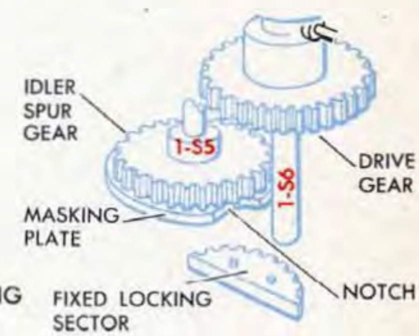


COARSE INTERLOCK IN LOCK POSITION

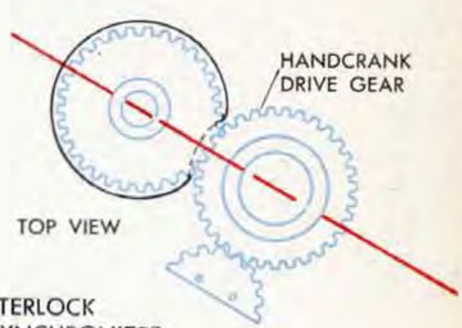
The fine interlock

The fine interlock consists of a masking plate on the bottom of the idler spur gear on shaft 1-S5. When the shift lever is in CONNECT AND SYNCHRONIZE position, the drive gear turns the shaft line to the spider and dials through this masked idler spur gear. The masking plate does not interfere with this operation.

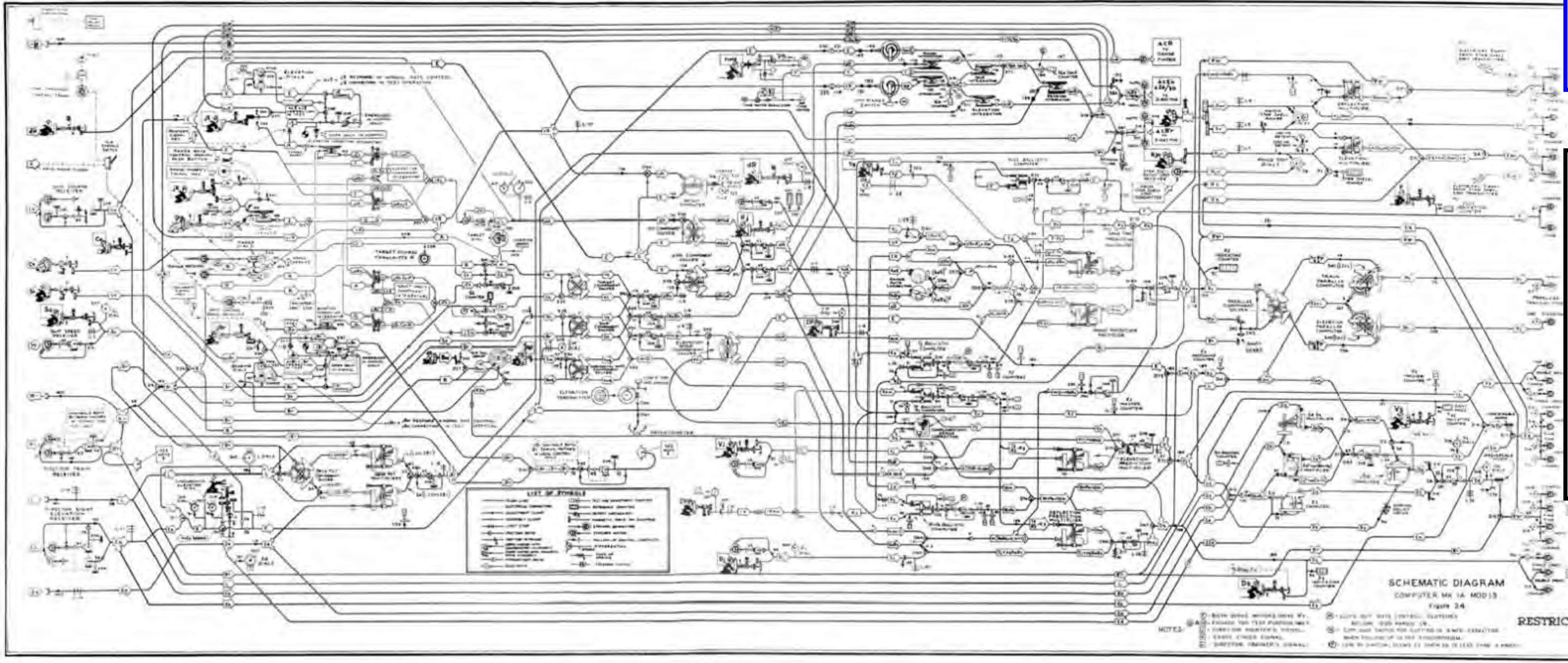
In LOCK position the drive gear must be lowered by the shift lever until it engages the fixed locking sector. The drive gear cannot be moved into mesh with the fixed locking sector until the notch in the masking plate lines up with the edge of the drive gear. When the dials are exactly matched at the index, the notch and drive gear are aligned. Thus, when the dials are synchronized, the notch allows the drive gear to drop into mesh with the locking sector.



LOCKING DETAIL



FINE INTERLOCK DIALS SYNCHRONIZED



SCHEMATIC DIAGRAM
COMPUTER MK 1A MOD 13
Figure 24

RESTRICTED

QUICK REFERENCE INDEX

More detailed breakdown on next two pages.

This page is hot linked. Click the page/subject you want. The file is also searchable. Enter the phrase you want in search block. If that does not work, try a different phrase OCR isn't perfect.

If link does not work, the page you want is in a different file. Return to original page to download.

APPENDIX

The Appendix contains the following two chapters:

LIMITS OF ACCURATE COMPUTATION

If the Computer Mark 1 had been designed to produce uniformly accurate outputs for the whole range of values of every input, and for all possible combinations of input values, it would have been several times its present size. In order to keep its size within practical limits, and for other design reasons, a number of approximate solutions were accepted.

The acceptance of the approximate solution instead of the true solution results in various errors. These errors are called "Class B" errors.

In general, approximate solutions are chosen to keep the Class B errors very small throughout the usual range of the input values, rather than to maintain a nearly uniform degree of accuracy for all input values. As a result, Class B errors are quite large in a few instances when certain inputs reach unusual values. The Trunnion Tilt Section of the Computer Mark 1, for example, computes highly accurate corrections when L and Zd are less than 10° and $E2 + L$ is less than 70°, but when L and Zd reach the unusual value of 20°, the Trunnion Tilt Corrections may contain errors as high as several degrees.

The Class B errors in a Computer are the result of deliberate decisions. These decisions are based on many considerations resulting from conditions at the time the instrument was designed or modified. The size of the instrument and the usual range of the input values have already been mentioned. The degree of accuracy of the inputs is another consideration. For example, there is no point in putting enough mechanisms into a Computer to handle *I.V.* corrections with a maximum error of only one part in a hundred, if the *I.V.* input, itself, represents an estimate which is probably in error by at least ten parts in a hundred.

The design characteristics of the equipment which uses the Computer outputs are other important considerations in the choice of Class B errors. For example, the 5"/38 cal. gun mounts can move in train at a maximum rate of 30° per second and in elevation at a maximum rate of 15° per second. The mounts will fall behind any gun order signals which change faster than this.

The limitations of the equipment using the Computer outputs were considered particularly in designing the Trunnion Tilt Section of the Computer Mark 1.

The effect of trunnion tilt on the Line of Fire is removed by corrections to Gun Train and Elevation. When the guns are at a high elevation, such as 80°, the amount of movement in train required to counteract the effect of 15° of Cross-level is about ± 56 degrees. On a destroyer the mounts would have to train 224° every nine seconds and reach a maximum rate of approximately 60° per second. It is clear that accurate Trunnion Tilt Corrections for Gun Elevation greater than 70° would be largely wasted. Partly for this reason, the Computer Mark 1 Trunnion Tilt Section computes accurately for values of Gun Elevation only up to 70 degrees.

The same consideration entered into the decision to compute accurate Trunnion Tilt Corrections only when Level and Cross-level were less than 15 degrees. Accurate stabilization of the guns for values of Level and Cross-level greater than 15° would often require higher maximum rates of Train and Elevation than can be provided by the hydraulic drives on the mounts.

Most of the Class B errors in the Computer Mark 1 are so small that for all practical purposes they can be ignored by the Computer and Director Operators. However, a few Class B errors can become large enough to be important considerations in deciding when the Computer Gun Orders are reliable enough to justify firing the guns. Computer Operators should know under what conditions these Class B errors will become large enough to affect the accuracy of the Computer outputs.

This chapter first describes the Class B errors which may *seriously* affect the accuracy of the Gun Orders. It then discusses a number of other Class B errors which cannot by themselves jeopardize the Gun Orders, but which may, under certain circumstances, become large enough to be taken into account by the Director and Computer Operators.

NOTE:
An accurate picture of the Class B errors of the Computer Mark 1 cannot be obtained from an inspection of the Class B errors in the fifteen A Test Problems. These A Test Problems are a mechanical check of the Computer, and not a representative set of operating problems. They show neither the largest possible Class B errors nor the average Class B errors.

THE LARGER CLASS B ERRORS

In general, the accuracy of the Computer Mark 1 outputs will begin to decline very sharply:

1. When Target Elevation exceeds 70°
2. When Level and Cross-level exceed 20°
3. If Rate Control is continued when Present Range is less than 1500 yards

Errors caused by Target Elevation values greater than 70°

There are cams in the Computer Mark 1 which compute the secant of *E* and *E2*. The secant curve rises so steeply as the angle nears 90° that it was considered impractical to cut cams for values of *E* above 70 degrees.

One of the secant cams is in the Integrator Group, where it is used to convert the measurement of Generated Angular Deflection from a slant plane into the horizontal plane.

When *E* goes above 70°, Generated True Bearing, $\triangle cB$, and Generated Relative Target Bearing, $\triangle cBr$, will be in error. If erroneous values of $\triangle cBr$ are used for Rate Control, they will result in false values of *Sh*, *dH*, and *A*.

The *jDd* Computer of the Trunnion Tilt Section computes the secant of $E2 + L$ up to 70 degrees. Generally speaking, the *jDd* Computer converts the measurement of *Ds* from a slant plane to the deck plane. When the value of $E2 + L$ exceeds 70°, the accuracy of the *jDd* computations will decline rapidly.

If the guns are fired as Target Elevation increases above 70°, the errors in the Gun Orders cannot be corrected by spotting, because the errors will increase at a rapidly increasing rate as Target Elevation increases. If spots are put in on the basis of bursts which were fired when *E* was 75°, and *E* has meanwhile increased to 80°, the errors in Gun Position and Fuze Time will have increased so much that the spots will be almost useless.

If firing is attempted with Target Elevation greater than 70°, it should be controlled so that the guns will fire at the midpoint of the roll. At this point, *L* and *Zd* will usually be at low values and error from the Trunnion Tilt Corrections will be at a minimum.

Errors caused by large values of Eb and Zd

The Trunnion Tilt Section is designed to compute accurately as long as Cross-level is less than 15°, Deflection is less than 20°, and Elevation plus Level is less than 70°. For greater values of these quantities, the Trunnion Tilt computations are partially in error.

The Deck Tilt Computer also has a limited accuracy, but the maximum errors here are smaller and are therefore discussed on the next page under the smaller Class B errors.

Errors caused by rate-controlling with Range less than 1500 yards

The Integrator Group in the Computer Mark 1 generates accurate changes of Target Position only when Range is between the values of 1500 yards and 22,500 yards. The errors introduced by rate-controlling with Range above 22,500 yards may be ignored, since they are small and do not affect the firing of the guns.

If Rate Control is continued when Range decreases to less than 1500 yards, serious errors in *Sh, dH,* and *A* will result.

When Range decreases to less than 1500 yards, the follower in the *1/cR* cam passes into the cam's outer constant radius. This cam follower positions the carriage of the *1/cR* Integrator. The speed of the output roller of the *1/cR* Integrator will therefore remain constant for all ranges below 1500 yards.

The output of the *1/cR* Integrator affects both Generated Bearing and Generated Elevation. If Rate Control is continued at ranges below 1500 yards, the Observed Elevation and Bearing Rates will be synchronized with false rates of Generated Elevation and Bearing, which can be speeded up only by fictitious increases in Target Speed and Rate of Climb.

THE SMALLER CLASS B ERRORS

Deck Tilt

During the sharp turns required for evasive maneuvers, the roll of the ship can be as great as 20° due to the combination of heeling over and roll and pitch. The *jB'r* output of the Deck Tilt Computer under these conditions can be in error up to approximately one degree.

Rate Control

In order to save mechanisms, the Rate Control Group gives a completely accurate solution for a constant Range and constant Elevation.

The correction inputs to the Rate Control Group are angular corrections *jE* and *jBr*. The conversion of these angular corrections into the linear corrections required by the Rate Control Computing Mechanism would necessitate the use of a secant cam multiplier, a reciprocal range cam, and several other mechanisms. Instead, the angular corrections are converted into *approximate* linear corrections by means of gear ratios. As a result of these and other approximations, the Rate Control Computing Mechanism corrects the Target Motion setup by a series of successive approximations.

Well-informed operators can speed up this process of approximation without running into danger of over-rate-controlling.

Prediction

The Prediction Section contains a great number of approximations, most of which have been discussed already in the chapter on the Prediction Section.

Parallax

The *1/R2* cam in the Parallax Component Solver computes the reciprocal of *R2* for values of *R2* down to 1500 yards. When *R2* is less than 1500 yards, the Parallax Corrections will be partially in error.

MODIFICATION DIFFERENCES IN THE COMPUTER MARK 1

There are two groups of differences in the various Computers Mark 1: *Mod Differences* and *Design Differences*. A *Mod Difference* is a difference involving a major change in design or operation, or any change in design or operation which adapts the Computer to a different use. A *Design Difference* is a difference in design or operation which affects all mods, or any difference of a minor nature.

Originally the Computer Mark 1 was designed for the 5"/38 cal. dual-purpose guns only. The mod differences in the early mods are those which adapt the Computer to the different mounts and different parallax needs of different installations. At the same time various other improvements were made, such as increasing the limits of various quantities, installing additional transmission units, etc. In later mods the Star Shell Computer was added, and in still later mods the Computer was adapted for the 5"/54 cal. guns, the 6"/47 cal. guns, and the 8"/55 cal. guns.

Each instrument has a *mod number* and a *serial number*. The *mod numbers* are assigned at the time the design work is done, and the *serial numbers* are assigned at the time of production. Because of this there is no relation between the mod number and the serial number of an instrument. An instrument with a higher mod number may reach production before one with a lower mod number. As a result, an instrument with a higher mod number may have a lower serial number than one with a low mod number. For example, Mod 13 was in production before Mod 8; therefore some Mod 13 instruments have serial numbers lower than some Mod 8 instruments.

This chapter describes the major differences characterizing each mod and lists the serial numbers of the first instruments which incorporate each of these and other differences. It also contains lists of pertinent FORDALT's, ORDALT's, and OD's.

Gene Slover's US Navy Pages

Quick Reference Index

MAJOR MODIFICATION DIFFERENCES

MOD 0

The Computer Mark 1 Mod O (blank space on the name plate) was designed for DD's with single mounts and was assigned to DD409 to 428 inclusive. Mod O had single-speed transmitters for *Vs* and *Ds*, computed Train Parallax Corrections based on *B'gr*, and had IN values of *Rj* limited to 1800 yards.

MOD 2

like Mod O, was designed for DD's with single mounts. It was similar to the Mod O, but differed from it in three ways: (1) An *So* Receiver was added and the upper limit of *So* was increased to 45 knots. (2) Bearing and Elevation Correction Indicating Transmitters were added. Previously a single pair had been used for both Auto and Indicating. (3) The quantity $L + Zd/30$ was added to the Elevation Correction output.

MOD 1

was designed for cruisers and battleships with twin mounts. It differed from Mod O and Mod 2 mainly in that: (1) It computed Train Parallax Corrections based on *B'r* instead of *B'gr*. (2) Double-speed transmitters were used for *Vs* and *Ds* instead of single-speed transmitters.

MOD 9

A spare Mod 1 became Mod 9 by ORDALT 1182, which added single-speed transmitters for *Vs* and *Ds*.

MOD 3

like Mod 1, was designed for cruisers and battleships. It was similar to the Mod 1 with the following major differences: (1) The upper limit of Generated Present Range was increased from 22,500 to 35,000 yards. (2) Provision was made for control of main-battery A.A. projectiles. (3) The *Vs*, *Ds*, *F*, and *Ph* transmitters were increased in size from 6 G's to 7G's.

The changed limits of other quantities are shown on the chart of Principal Differences, Ordnance Drawing No. 210535.

MOD 10

A spare Mod 3, Ser. No. 100, became Mod 10, also by ORDALT 1182.

MOD 4

was essentially the Mod 3 with the addition of a Star Shell Computer.

MOD 5

was the Mod 2 with the addition of a Star Shell Computer and the equipment for the computation of Elevation Parallax for a horizontal base. Only two Mod 5's were made. They were Ser. Nos. 58 and 59, and both were assigned to the USS Hornet (CV8).

MOD 6

was essentially the Mod 2 with the addition of a Star Shell Computer.

MOD 7

was designed for the Essex Class carriers having both single and twin mounts. The Mod 7 differed from the Mod 5 in that it had both single-speed and double-speed transmitters for *Vs* and *Ds*.

"UNIVERSAL" MOD 7

To speed production of Computers Mark 1, the limits and features of Mods 4, 6, and 7 were incorporated into one instrument. This instrument was designated Mod 7, but is called the "Universal" Mod 7. The first "Universal" Mod 7 instrument had Ser. No. 216. It differed from the "old" Mod 7 in that it had the larger limits of *Rj* and *F* as in Mod 4 and also had a shift gear with which to select either *B′r* or *B′gr* for use in the Parallax computations.

A series of alterations were then made to the "Universal" Mod 7 without changing the Mod number.

ORDALT 2116A later ordered all existing "Universal" Mod 7's changed to become Mod 13's.

MOD 13

is like the "Universal" Mod 7 except that the Range Receiver has been changed from values of 36,000 and 2000 yards to 72,000 and 2000 yards, and the Radar Range Receiver has been eliminated. Both these changes were made by ORDALT 2116A.

MOD 11

was like the Mod 7 except that Elevation Parallax was computed for a zero vertical base. All Mod 11's were ordered changed to Mod 13's.

MODS 8 and 12

are for the 5″/54 cal. dual-purpose gun. Mod 12 has a zero vertical base.

MODS 14 and 16

are for the 6″/47 cal. gun.

MOD 15

is for the 8″/55 cal. gun.

MODIFICATION DIFFERENCES IN THE STAR SHELL COMPUTER MARK 1

Star Shell Computer Mark 1 Mods O and 1 are used with Computer Mark 1 Mods 4, 5, 6, 7, 11, and 13.

The Mod 1 supersedes the Mod O. In the Mod 1, Elevation and Deflection Handcranks and Elevation and Deflection Spot Dials were added. The Gun Order Dials and the Fuze Counter are on the front where they can be observed through a large window. The Range Spot limit is changed to IN 2857 – OUT 1500. The first Star Shell Computer Mark 1 Mod 1 had Ser. No. 621.

Star Shell Computer Mark 1 Mod 2 is like the Mod 1 except that it was designed for the 5"/54 cal. guns. The Match Star Shell Range Dials are calibrated differently and the Range Spot limit is IN 2700 – OUT 1500. The Mod 2 is used with Computers Mark 1, Mods 8 and 12.

PERTINENT SERIAL NUMBERS

Computer Mark 1 Serial Numbers

58 Star Shell Computer Mark 1, Ser. No. 1, was installed with Computer Mark 1 Mod 5, Ser. No. 58.

101 First instrument originally equipped with a Bearing Filter and a modified Ship Course Receiver. ORDALT 1172 equipped Mods 1 through 6 below Ser. No. 101 with the Bearing Filter and modified Ship Course Receiver (OD 4178).

101 First instrument equipped with AUTO Range Rate Control. Alteration of Rate Control on instruments below Ser. No. 101 is given on OD 4185.

101 First instrument originally equipped with a Radar Range Receiver in place of the Battle and Shell Order Annunciators. ORDALT 1080 made this change on instruments below Ser. No. 101. The Radar Range Receiver was later removed by ORDALTS 2116 and 2116A.

216 First "Universal" Mod 7 instrument.

234 First instrument originally equipped with a Target Course Follow-up instead of a Target Angle Follow-up. Instructions for making this change on all instruments below Ser. No. 234 are contained in OD 4239.

371 Instruments with Ser. Nos. 371, 373 and above are not equipped with Powder Fuze Ballistic Cams.

390 First instrument originally equipped with an *I.V.* lower limit of 2350 f.s. instead of 2450 f.s. Instructions for making this change on all instruments below Ser. No. 390 are contained in OD 5106.

390 First instrument to have Target Elevation, *E*, lower limit of −25 degrees. First instrument to have an intermittent drive added in the *E* line to the sec *E* cam. Instruments below Ser. No. 390 were not altered.

421 First instrument originally equipped with a Target Course Transmitter instead of a Target Angle Transmitter. A-232 was replaced by A-258. Instructions for making these changes in instruments below Ser. No. 421 are contained in ORDALT 1995 and OD 5108.

Ser. No. 421 was also the first instrument supplied with a Target Course Indicator instead of a Target Angle Repeater. Instructions for changing the Target Angle Repeater to a Target Course Indicator are contained in ORDALT 1994 and OD 5107.

435 First instrument with larger shaft verniers on the $1/cR$ and sec E lines. A-148 and A-150 were eliminated. Instructions for changing to the new sec E shaft in Ser. Nos. 1-434 and new $1/cR$ shaft in Ser. Nos. 220-434 are contained in FORDALT 18.

435 Target Control signal lamp, resistor, and relay were omitted from Ser. No. 435 and up.

435 First instrument equipped with two indicating E Counters, one located in the Computer Section and one in the Corrector Section. A-259 and A-260 were added.

501 First instrument with the original relocation of the Eb Receiver resistor. ORDALT 2123 ordered the relocation of the resistor in instruments with Ser. Nos. 500 and below.

518 Last instrument supplied with Solution Indicator Generators.

568 First instrument originally designated Mod 13. Previous Mod 7 instruments were modified by ORDALT 2116A to change them to Mod 13.

781 First instrument designed for more accurate Fuze computation.

811 First instrument with $I.V.$ Correction going into the $Tf/R2$ Ballistic Computer.

List of FORDALT's

5 Frame No. 66 Damper. Redesign using 2 bearings to prevent wobble.

6 Frame No. 50 Damper. Redesign using 2 bearings to prevent wobble.

8
- a Change *A* Transmitter to *Ct* Transmitter.
- b Design Target Course Indicator to be mounted on Star Shell Computer.
- c Connected by local cable.

Began with Ser. No. 420.

10 Spot Transmitter Mark 1. Change for red light illumination.

11 Star Shell Spot Transmitter Mark 1. Change for red light illumination.

12 Range Spot Transmitter Mark 2. Change for red light illumination.

18 Redesign vernier adjustments on shafts 44-S42 and 44-S44 to prevent breaking of shaft. Began with Ser. No. 435.

26 Photographic type dials. Began with Star Shell Computer Ser. No. 521. Began with Computer Mark 1, Ser. No. 751.

30 Change in value of Range Receiver and removal of Radar Range Receiver. Mod 7 to become Mod 13.

32 Removal of Solution Indicator Generators. Began with Ser. No. 519.

35 Redesign Time Motor Regulator.

36 Relocation of *Eb* Receiver Resistor. Ser. No. 501.

42 Redesign 5-inch integrator to provide a more rigid mounting for disk bearing.

44 Star Shell Computer Mark 1 Mod 1 to incorporate function of Star Shell Spot Transmitter. Began with Ser. No. 621.

79 Change of Range Receiver Mark 1. Add 4 Mfd Capacitor to increase torque of output.

96 Oldham Couplings. Shaft extensions longer to prevent disengaging from shock.

106 Star Shell Computer Mark 1 Mod 1 to receive spots from Star Shell Spot Transmitter.

108 New Fuze computation. Ser. No. 781 up of Mod 13, as in Mods 8 and 12.

126 Guard to protect *jB'r* and *Vz* Follow-up contacts.

129 Improve performance of Servo Motor Control by increasing spring pressure and designating specific oiling points. Change wire diameter from 0.020 to 0.026.

156 Improve Class B errors by correcting *Tf/R2* for effect of variation of *I.V*.

161 Add Range Spot Dial to *Vj* Dial IN 180 – OUT 342.5 (= 24,600 yards).

176 Relocate *B'r* Resistor to prevent overheating of *Dd* Friction.

List of ORDALT's

1080	Radar Range Receiver replaces Battle and Shell Order Annunciators. Later removed by ORDALT 2116A.
1172	Bearing Filter and modified Ship Course Receiver added below Ser. No. 101, except Mod 0.
1182	Add *Vs* and *Ds* single-speed transmission to spare Mod 1 then designated Mod 9, and to spare Mod 3 then designated Mod 10, for CV3.
1224	Addition of Selector Drive Mark 1 replacing Cross-level shaft.
2116	Change all Mods to receive Range at 2000 and 72,000 yards per revolution.
2116A	Change Mod 7 to Mod 13. Remove Radar Range Receiver. Add ORDALT record plate.
2117	Star Shell Computer. Increase lower limit of *Rjn* to accommodate control of smoke projectiles.
2123	Relocate *Eb* Receiver Resistor to prevent overheating of gearing.
2125	Replace Synchronize Elevation brake springs with springs giving approximately twice the pressure.
2126	Change *So* Receiver to 30 knots per revolution on Ser. No. 627.
2127	Add Deflection scale to Generated Bearing Crank.
2266	Change Bearing Correction Transmitter from 5G to 6G and Elevation Correction Transmitter from 5G to 6DG on Mod 0 machines.
2283	For CL55 type. Instructions for 6"/47 A.A. fire incorporating use of Computer Mark 28. FICO Drg. No. B-4147.
2321	Relocation of *B'r* Resistor to prevent damage to *Dd* friction by overheating.
5224	Change Mod 11 to receive Range at 72,000 and 2000 yards per revolution.

List of OD's

4178 Computer Mark 1 Mods 1 through 6. Installation Instructions for Modified Ship Course Receiver and Bearing Filter.

4185 Computer Mark 1 Mods 0 through 6, below Ser. No. 101. Alteration of Rate Control System.

4233 Computer Mark 1, Ser. Nos. 1 through 100. Instructions for changing Target Angle Follow-up shaft.

4236 Selector Drive Mark 1. Instructions for Installation and Operation.

4239 Computer Mark 1. Instructions for converting Target Angle Follow-up to Target Course Follow-up.

5106 Computer Mark 1 and Modifications. Instructions for altering *I.V.* limits from 2600 and 2450 to 2600 and 2350 f.s.

5107 Target Course Indicator Mark 1. Conversion from Target Angle Repeater Mark 1.

5108 Computers Mark 1 Mod 4, 5, 6, and 7. Below Ser. No. 421. Alteration to provide for mounting of, and operating with, Target Course Indicator Mark 1.

5116 Computer Mark 1 Mod 3 and 10. Alteration to provide for mounting of, and operating with, Target Course Indicator Mark 1.

5117 Computer Mark 1 Mod 0, 1, 2, and 9. Alteration to provide for mounting of, and operating with, Target Angle Control Switch.

5127 Instructions for providing red illumination on Ford instruments.

5146 Computer Mark 1 Mod 4, 5, 6, and 7. Below Ser. No. 519. Instructions for removal of Solution Indicator Generators and connecting material.

5158 Computer Mark 1 Mod 7. Instructions for converting to Mod 13.

DETAILS OF MODIFICATION DIFFERENCES

$Vf + Pe$ Ballistic Computers

In Computers Mark 1, Mods 0 through 10, 13, and 15, *Pe* is computed for a vertical base of 30 feet.

In Computer Mark 1, Mod 14 the vertical base is 40 feet. In Mod 16 the base is 15 feet.

Computers Mark 1 Mods 11 and 12 were designed for ships on which the Directors were located at approximately the same height as the guns. There was no need for a computation of Elevation Parallax, *Pe*. In these Mods, therefore, *Vf* Ballistic Computers replace the $Vf + Pe$ Ballistic Computers. The output of the *Vf* Ballistic Computer is simply Superelevation, *Vf*.

Fuze Computation

On Computers with Ser. No. 781 and up, more accurate computation of Fuze Setting Order was incorporated.

The Fuze Setting Order is actually a value computed in advance for the value of Time of Flight at the instant of firing.

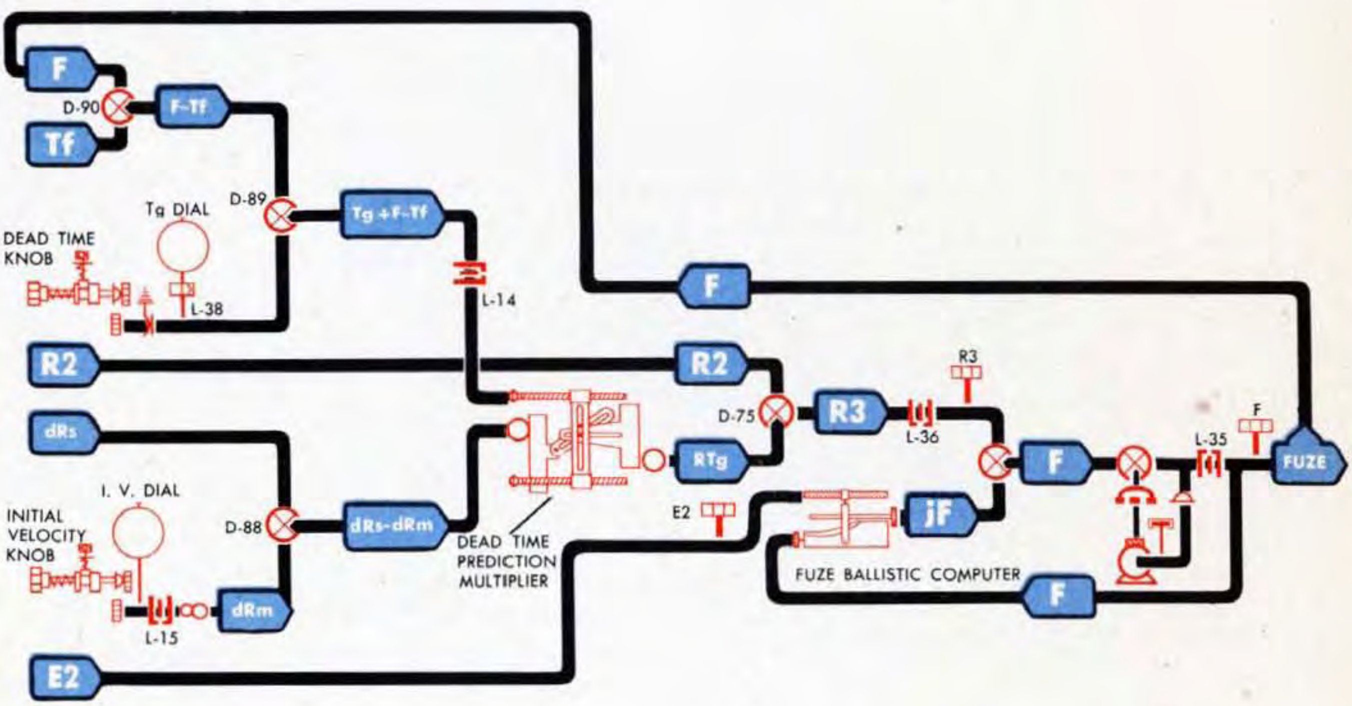
The output of the Dead Time Prediction Multiplier is RTg. The old equation was $RTg = K \times dR \times Tg$. The new equation is $RTg = K\ (dR + dRxe)\ (Tg + F - Tf)$. For convenience of design, the factor $(dR + dRxe)$ is computed as $(dRs - dRm)$.

The time elapsed between the instant the projectile is removed from the shell hoist and the instant of firing is known as Dead Time, Tg. Added to Dead Time is the difference between Time of Flight when the projectile is removed from the shell hoist and Time of Flight at the instant of firing. This difference is expressed by $(F - Tf)$. Thus the total time correction is $(Tg + F - Tf)$. The correction to Time of Flight is then the product of Total Range Rate and this total time correction.

The subtraction of Initial Velocity Correction, *dRm*, from Prediction Range Rate, *dRs*, produces Total Range Rate for the computation of RTg.

The value RTg is added to $R2$ to form $R3$ which is the Fuze Range.

Further accuracy of computation is accomplished by turning the Fuze Ballistic Cam by F rather than $R3$. The cam output, jF, is added to $R3$ to form F.



Rate Control on Computers Mark 1 with Serial Numbers below 101

On Computers below Ser. No. 101, the Rate Control System was altered for the purpose of improving the action and increasing the speed of solution of the Rate Control System. The instructions for making this alteration are given in OD 4185.

The wiring connecting the Range Rate Control Time Clutch was disconnected so that the Range Rate Correction Integrator carriage remains at the 5-second offset.

Originally, with the Change of Range Switch at ON RANGE FINDER, the Range Motor was energized only when the Range Operator in the Director closed the signal circuit. When altered, the power supply to the Range Motor was disconnected from the signal circuit and connected to the Range Switch. With this arrangement the Range Motor drives whenever the switch is at ON RANGE FINDER.

With the Time Clutch to the Range Rate Correction Integrator disconnected, it becomes possible to match Generated Range to Observed Range continuously. When the signal to commence tracking is received, the Computer Operator should turn the Change of Range Switch from ON RANGE FINDER to OFF. If the Observed Range Dials and the Range Finder Signal indicate that the correct Range is being received continuously, the Computer Operator should turn the Generated Range Handcrank in its IN position and continuously match Generated Range with Observed Range.

If the received values of Range are intermittent, it may become necessary to over- or under-rate-control. The Generated Range Dials should be matched to the Observed Range Dials only when the Range Finder Signal is on. When the rate of divergence between Generated and Observed Range is large, that is, when the Dials move relatively far out of synchronism in a relatively short time, the Operator should over-correct.

To over-correct he should do the following:

1. With the Generated Range Crank IN, turn until the index of the fine ring dial passes and overtakes the arrow on the inner dial.

2. Turn the ring dial back until the index matches the arrow on the inner dial *without putting in any rate correction.* This can be done either by shifting the Range Switch to ON RANGE FINDER until the dials are matched and then shifting it back to OFF, or by pulling the Generated Range Crank OUT against spring pressure, and turning it in the OUT position.

If the rate of divergence between the Generated and Observed Dials is small, the Operator should under-correct in a similar manner.

The wiring was further changed to enable the Computer Operator to cut out Bearing and Elevation Rate Corrections by means of the Target Speed Handcrank while the Control Switch was at AUTO. The new connections are such that the *jE* and *jBr* clutches will open when the Target Speed Handcrank is put in HAND.

If the Operator desires to discontinue rate control from the Director while in Automatic Control, he shifts the Target Speed Handcrank to HAND. Shifting the handcrank back to AUTO restores Director rate control.

If the Control Switch is at SEMI-AUTO and the Operator desires to change to AUTO control, he should do the following:

1. Shift the Target Speed Handcrank to HAND.

2. Turn the Control Switch to AUTO until the Generated Dials are synchronized.

3. Shift the Target Speed Handcrank to AUTO.

If the Control Switch is at SEMI-AUTO and the Operator wishes to shift to LOCAL, he should do the following:

1. Shift the Target Speed Handcrank to HAND.

2. Turn the Control Switch to AUTO, until the Generated Dials are synchronized.

3. Turn the Control Switch to LOCAL.

Remote control of Target Angle

Starting with Mod 4, the Computer Mark 1 was equipped with a set of relays to effect remote-control slewing of Target Angle. The system was completed with an auxiliary unit called the Target Angle Repeater Mark 1 which was mounted at the Control Officer's Station in the Director Mark 37, and a Target Angle Transmitter within the Computer. The purpose of the system was to permit a quick setup of estimated Target Angle when shifting to a close target.

Soon the need for a Target Course Indicator developed. Starting with Ser. No. 421, the Target Course Indicator replaced the Target Angle Repeater and a change in gearing changed the Target Angle Transmitter to a Target Course Transmitter. ORDALT 1995 (OD 5108) altered the transmitters on Computers Mark 1 below Ser. No. 421. The Target Angle Repeaters were changed to Target Course Indicators by ORDALT 1994 (OD 5107).

Mod 3 instruments were modified by OD 5116 for Target Course control.

OD 5117 installed a Target Angle Control Switch to slew Target Angle on Mods 0, 1, 2 and 9.

Lower Limit of *I.V.*

The Computers below Ser. No. 390 had a lower limit of 2450 f.s. for *I.V.* It was found that old rifles at cold temperatures called for a lower *I.V.* The present limit is 2350 f.s. Computers below Ser. No. 390 were to be altered, as per OD 5106. On the Computers not altered, it is necessary to introduce Range Spots whenever the *I.V.* is below 2450 f.s.

Control of Star Shell Fire without a Star Shell Computer

On installations not equipped with the Star Shell Computer, a Star Shell Data Plate supplies the necessary information. The Star Shell Data Plate gives Sight Angle and Fuze Setting Orders for firing Star Shells at various values of Advance Range.

Firing a Search Spread

When firing a search spread, all guns are used to fire star shells. With the Sight Angle and Fuze Handcranks in the IN position, set the counters at the values given opposite the value of Advance Range to transmit gun orders from the Computer to the guns. Approximations are necessary for uneven values of Advance Range. A plotted curve may be employed to obtain these approximations.

Firing Star Shells from only part of a battery

When firing star shells from one or more guns and firing regular service projectiles from the remainder of the battery, another method is employed. Sight Angle and Sight Deflection must be left undisturbed in the Computer so that regular gun orders are transmitted to the guns firing service projectiles. The Searchlight Corrector may be used to transmit gun orders to the star shell gun. The Searchlight Corrector normally transmits Director position plus Level and Cross-level corrections. Spots introduced into the Searchlight Corrector would make its output correspond to the proper values for firing star shells. The Elevation Spot would be Sight Angle given on the Star Shell Data Plate opposite the Computer value of Advance Range, minus 2000 minutes. The Deflection Spot would be the value of Sight Deflection as read on the Computer *Ds* Counter, minus 500 mils and converted into degrees and minutes. A chart may be laid out to speed this computation. These spots are telephoned to the Director for introduction into the Searchlight Corrector. Additional spots may be added to the Searchlight Corrector to correct for wind and other errors if necessary. Fuze Setting Order from the Star Shell Data Plate may be telephoned to the gun mount firing the star shells.

Elevation Lower Limit of − 5 Degrees

On Computers below Ser. No. 390 the lower limit of L-12 is −5 degrees. Extra precaution must be exercised in the operation of these Computers to avoid slamming into the Elevation limit stops while slewing the Director. On these instruments, the Director Slew Sight is secured at a minimum value around −20 degrees. Since the Computer lower limit is −5°, there is considerable danger of slewing into the lower limit in the Computer if the slew key is closed after all the circuits have been energized but the Slew Control has not been brought up to the horizontal position.

Another precaution must be exercised. The Computer should not be set up to receive Director Elevation if either the Computer is in LOCAL or if Level is not feeding into the Computer. In either case there is danger of slewing into the ends of the limit stops.

Suppose that Level is not feeding into the Computer and that the Level angle is 15° at the instant that the Control Officer slews the Director down to an angle of 5 degrees. The resultant angle would then be −10 degrees. The Computer Elevation line would slam into the −5° lower limit with the possibility of damage to the gearing, or, as usually happens, of causing A-59 to slip. A-59 is an inaccessible assembly clamp which was redesigned in later instruments to prevent slippage.

Again suppose that Level is feeding into the Computer but that Director Train is not being received either because the Computer is in LOCAL or because $B'r$ is shut off at the switchboard. Further suppose that the Director is trained 180° from the $B'r$ input to the Stable Element. In such a setup, Level of the opposite sign would be measured and the situation would be doubly as dangerous as not having Level feed in at all.

The following precautionary measures are recommended:

1. Loosen the Synchronize Elevation Knob holding friction until there is just enough friction to hold the Synchronize Elevation Dials matched. Then E will back out of the synchronizing differential D-12 whenever either limit of L-12 is hit.

2. Leave Director DC turned OFF until the Control Officer has the Slew Sight released from the secure position and is ready to slew to the Target.

3. Do not receive Director Elevation unless Director Train and Level are also being received

TABLE OF MODIFICATION DIFFERENCES

Mod No.	Ser. Nos.	Gun	Ship	Pe Base	Dip Base	Parallax driven by	Star Shell Computer	Present Range	Advance Range	Target Height	Range Spot	Mech. Fuze	Time of Flight	Own Speed	I.V.	Elevation Spot	Elevation	Ds	Vs	cR	E	R2	So	Radar Range	Range	L + Zd/30 Shaft	Train Parallax	Elevation Parallax	Parallax Range	Sight Angle minutes	Sight Deflection mils	Fuze seconds	Elevation and Bearing Correction	B'gr Information	Solution Indicator	Mod No.
	Miscellaneous							Limits										Intermittent Drives					Receivers				Transmitters									
0	1-20	5"/38 single	DD's Aux.	30 feet	17.83 yards	B'gr	None	0 22,500	1500 18,000	0 25,000	IN 1800 OUT 1800	0.60 45.05	1.80 61.80	0 40	Originally 2450-2600; changed to 2350-2600 by OD 5106	UP 180 DOWN 180	−5 +85	320 680	2000 3800	None	None	None	None	108,000-yard Receiver in Mods 2-7 Ser. Nos. 101 and up Installed in Ser. Nos. 1-100 by ORDALT 1080 All removed by ORDALT 2116A	Originally 2000 and 36,000 yards Altered to 2000 and 72,000 yards by ORDALT 2116A Ser. Nos. 216-567 become Mod 13	None	6 G's @ 30°	None	None	6 G's @ 2400	6 G's @ 442.24	6 G's @ 2 and 100	ORDALT 2266	None	None	0
2														0 45									21.8 34.5 40.0			Provided							6 G's @ 5° Auto. and 5 G's @ 10° Ind.			2
1	21-28 45-56	5"/38 twin	BB's CL's			B'r												None	None											6 G's @ 200 & 7200	6 G's @ 100 & 4000					1
9	29	5"/38 both	CV3																				30.0 34.5							ORDALT 1182	ORDALT 1182					9
3		5"/38 twin	BB's 58-60					0 35,000	500 18,000	0 50,000	IN 12,000 OUT 1800	0.60 55.00	0.60 60.60							750 22,500			30.0 34.5				7 G's @ 30°			7 G's @ 200 and 7200	7 G's @ 100 and 4000	7 G's @ 2 and 100				3
10	100	5"/38 both	CV3																											ORDALT 1182	ORDALT 1182					10
4	Below 101 Above 100	5"/38 twin	CL's CA's BB's				Star Shell Computer supplied except on some early Mods 4 and 6 Mk 1 Mod 0 Ser. No. 1-620 Mk 1 Mod 1 Ser. No. 621-up																40.0							7 G's @ 200 and 7200	7 G's @ 100 and 4000				Originally provided; removed by OD 5146	4
6		5"/38 single	DD's			B'gr					IN 1800 OUT 1800	0.60 45.00						320 680	2000 3800				25.0 40.0							7 G's @ 2400	7 G's @ 442.24					6
5	58-59		CV8																				34.5					7 G's @ 10°								5
"Old" 7	187-188 193-200	5"/38 both	CV's DD's																				40.0							Both 6 G's @ 2400 and 6 G's @ 200 and 7200	Both 6 G's @ 442.24 and 6 G's @ 100 and 4000					"Old" 7
"Univ" 7	216-389 390-518 519-567		All			Either B'gr or B'r selected by A-242					IN 12,000 OUT 1800	0.60 55.00																								"Univ" 7
11	*			0											2350 2600									None	2000 and 72000 yards										None	11
13	568-780 781-810 811-			30 feet																																13
8	*	5"/54	CVB		22 yards		Star Shell Computer Mk 1 Mod 2		500 20,000			0.60 49.00	0.60 50.60		2400 2650	UP 342.5 DOWN 180	−25 +85	None	None		−2 +85	1500 18900								7 G's @ 200 and 7200	7 G's @ 100 and 4000					8
12	*			0	13 yards																															12
15	*	8"/55	*	30 feet	59 feet				*			0.60 45.60			2400 2700	UP 180 DOWN 180		390 590	2000 4460									None	7 G's @ 0.001	7 G's @ 100 and 3600	7 G's @ 210.48	7 G's @ 20/7 and 360/7		7 G's @ 10°		15
14	*	6"/47		40 feet	70 feet							0.60 49.00			2250 2720			None	None									7 G's @ 10°	*	7 G's @ 200 and 7200	7 G's @ 100 and 4000	7 G's @ 2 and 100				14

*Information not available at time of printing.

GLOSSARY of QUANTITIES and SYMBOLS

In the Mark 37 System, those quantities which can be rigidly defined have fire control symbols.

A quantity may be broken down into a basic quantity and modifying quantities. For example, the quantity "Own Ship Speed" consists of the basic quantity "Speed" and the modifying quantity "of Own Ship."

The fire control symbols may be broken down in the same way: into basic symbols for the basic quantities and modifying symbols for modifying quantities.

Capital letters are used for the basic symbols, small letters for the modifying symbols. For example, the symbol for "Own Ship Speed" is *So*; capital "*S*" is the symbol for the basic quantity "Speed", and small "*o*" is the symbol for the modifying quantity "of Own Ship."

This chapter lists separately the basic symbols and the modifying symbols used in building the symbols for the Gun Director Mark 37 System. Familiarity with the meaning of these individual letters will make the memorizing of the symbols much easier.

In the definitions given here, the following terms are understood:

a. The term "Line of Sight" is used to designate the Line of Sight from the Director to the Target.

b. The term "deck plane" means the standard reference plane of Own Ship.

c. The term "horizontal plane" refers to the horizontal plane through the Director sights. The solution given by the Computer is based upon this plane.

d. The term "plane through the Line of Sight (or Fire)" refers to the plane *containing* the Line of Sight (or Fire).

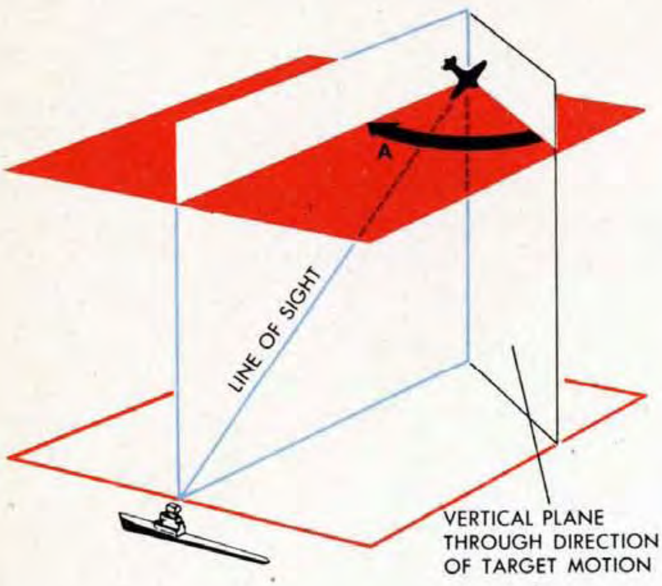
BASIC SYMBOLS

A	Target Angle
B	Bearing (of Target, unless modified), measured in the horizontal plane
B′	Same as *B*, but measured in the deck plane
C	Course, measured in the horizontal plane
D	Lateral Deflection (angular measure)
E	Elevation (of Target, unless modified), measured in the vertical plane
E′	Same as *E*, but measured in a plane perpendicular to the deck
F	Fuze Setting
H	Height of Target (normally in feet)
K	K_1, K_2, etc. Constants
L	Level Angle, measured in the vertical plane
P	Parallax
R	Range
S	Speed
T	Time
V	Elevation Prediction (angular measure)
X	Horizontal deflection component of velocity perpendicular to the vertical plane through the Line of Sight
Y	Horizontal range component of velocity in the vertical plane through the Line of Sight
Z	Cross-level Angle

NOTE: In general, a *prime* after a basic symbol indicates the quantity is measured in the plane of the deck of Own Ship, or in a plane perpendicular to the deck of Own Ship.

MODIFYING SYMBOLS

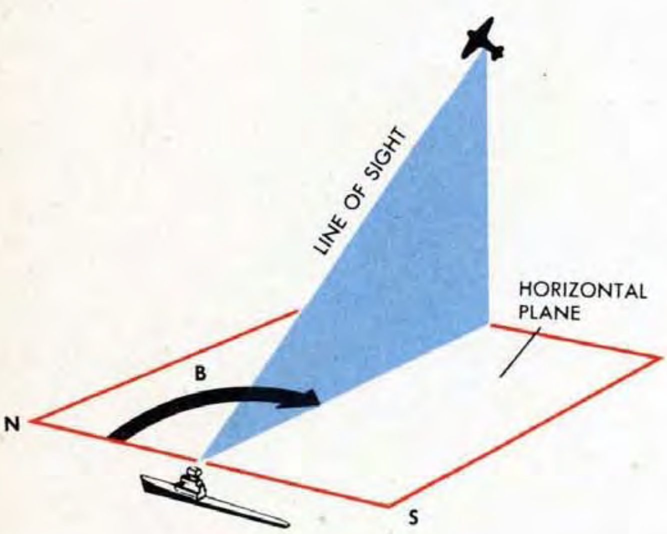
b	Of Director
c	Before a quantity means the value of that quantity as generated by the mechanism, as opposed to the *observed* value of the same quantity. After a quantity means relative to rate control.
d	Before a quantity means a time rate of change of that quantity. After a quantity means in or relative to the deck plane or plane perpendicular to the deck.
e	Elevation
f	Due to standard trajectory
g	Of Gun
h	Horizontal projection of
j	Before a quantity means a correction or partial correction to that quantity, usually generated by the mechanism. After a quantity means arbitrary correction (spot) to that quantity.
m	Loss of Initial Velocity
o	Of or due to Own Ship
r	Relative to Own Ship
s	Relative to the Line of Sight, or in a slant plane. (Since several slant planes may be used, each definition should specify the plane used.)
t	Of or due to Target
v	Vertical projection of
w	Of or due to Wind
z	Of or due to Cross-level
f( )	Function of the quantity in parentheses
Δ	Before a quantity means change in that quantity during some specific time. Increment of a quantity.
$\int$	Before a quantity means the integral of that quantity
2	After a quantity indicates that it is the predicted value of that quantity for advance position; i.e., for the instant a projectile, which is fired at the present time, hits (bursts for anti-aircraft fire).
3	After a quantity indicates that it is the predicted value of that quantity for fuze position; i.e., for the instant a projectile, fired dead time seconds from the present time, hits (bursts for anti-aircraft fire).



A TARGET ANGLE

The angle between the vertical plane through the direction of Target Motion and the vertical plane through the Line of Sight, measured in the horizontal plane, clockwise from the direction of Target Motion.

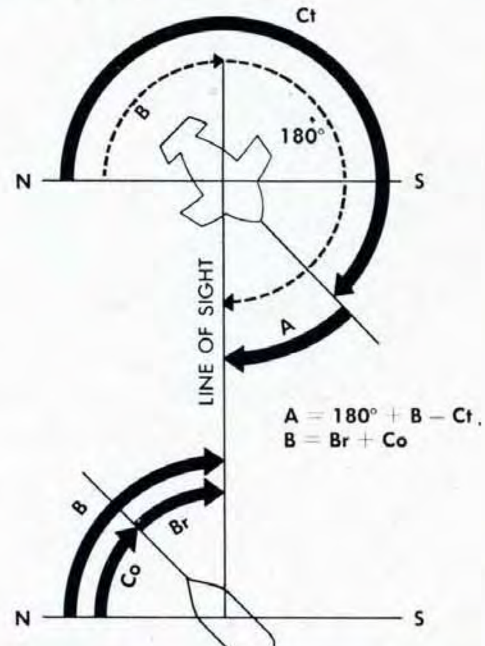
$$A = 180^\circ + B - Ct$$



B TRUE TARGET BEARING

Compass direction of the Line of Sight.

$$B = Br + Co$$



ΔcB INCREMENT OF GENERATED TRUE BEARING

Change in True Bearing computed by the instrument.

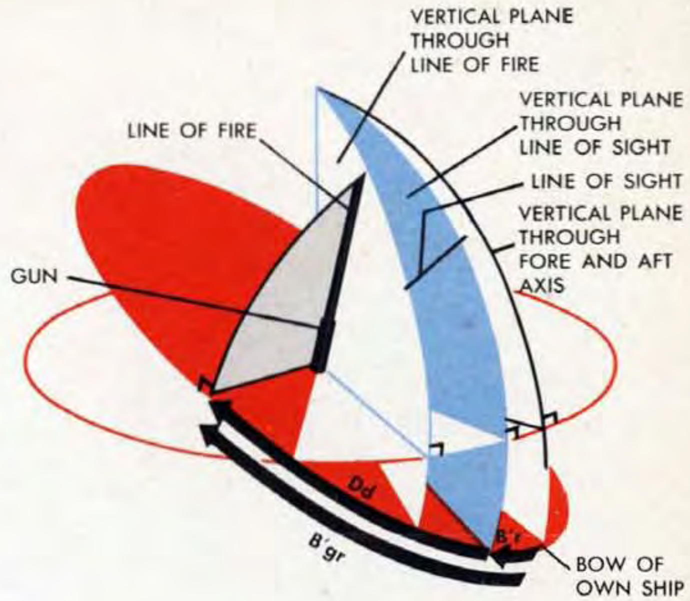
jBc LINEAR DEFLECTION RATE CORRECTION

Rate Control Correction affecting Linear Deflection Rate.

B'gr GUN TRAIN ORDER

The ordered angle between the fore and aft axis of Own Ship and a plane through the Line of Fire at right angles to the deck, measured in the deck plane clockwise from the bow, without correction for horizontal parallax.

$$B'gr = B'r + Dd$$



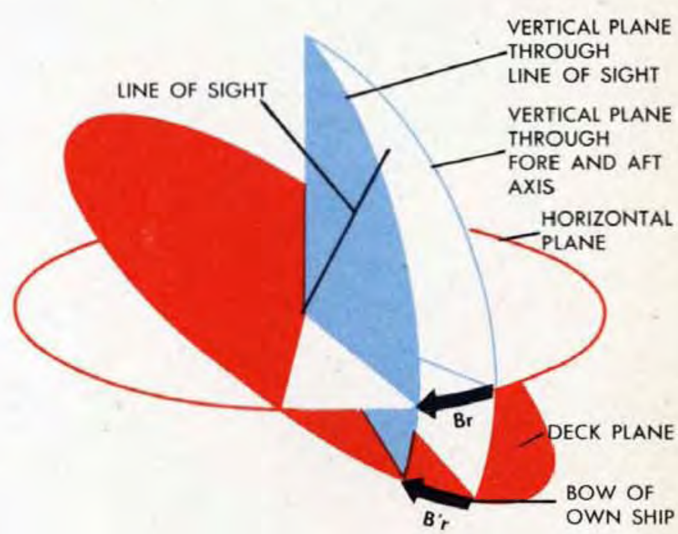
Br RELATIVE TARGET BEARING

The angle between the vertical plane through the fore and aft axis of Own Ship and the vertical plane through the Line of Sight, measured in the horizontal plane clockwise from the bow of Own Ship.

$$Br = B'r + jB'r$$

B'r DIRECTOR TRAIN

The angle between the vertical plane through the fore and aft axis of Own Ship and the vertical plane through the Line of Sight, measured in the deck plane clockwise from the bow of Own Ship.



cBr GENERATED RELATIVE TARGET BEARING

Relative Target Bearing computed by the instrument.

$$cBr = jBr + \triangle cBr$$

cB'r GENERATED DIRECTOR TRAIN

Director Train computed by the instrument.

$$cB'r = cBr - jB'r$$

△cBr INCREMENT OF GENERATED RELATIVE TARGET BEARING

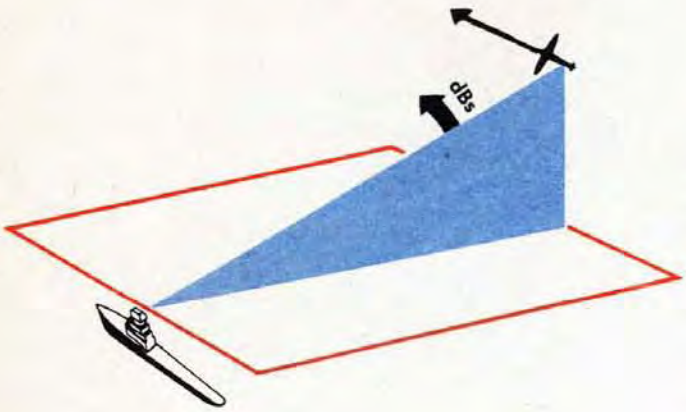
Changes of Relative Target Bearing computed by the instrument.

$$\triangle cBr = \triangle cB - Co$$

△cB'r INCREMENT OF GENERATED DIRECTOR TRAIN

Changes of Director Train computed by the instrument. (Bearing Correction.)

$$\triangle cB'r = \triangle cBr - jB'r$$



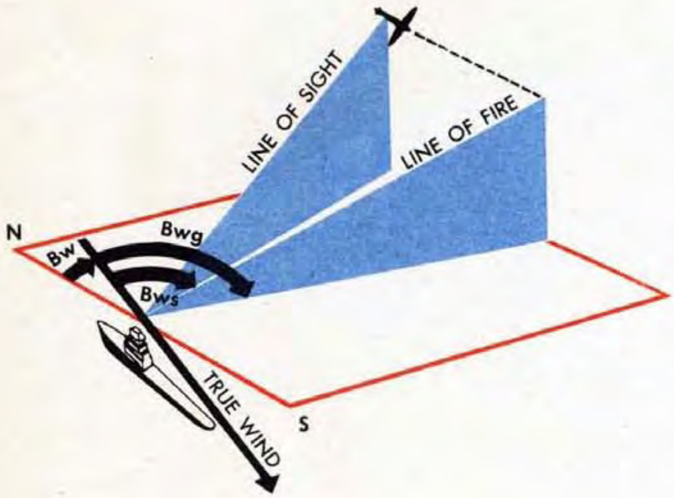
jBr INITIAL OR CORRECTIVE SETTING OF GENERATED RELATIVE TARGET BEARING

jB'r DECK TILT CORRECTION

Correction to Director Train, *B'r*, for the effect of Deck Tilt, used to refer Director Train to the horizontal plane.

dBs BEARING RATE IN SLANT PLANE

Bearing Rate measured in the slant plane through the Line of Sight and at right angles to the vertical plane through the Line of Sight. (Does not exist separately in the mechanism.)



Bw WIND DIRECTION

The compass direction *from* which the Wind is blowing.

Bwg PREDICTED WIND ANGLE

The angle between the direction *from* which the Wind is blowing and the vertical plane through the Line of Fire, measured in the horizontal plane clockwise from the direction *from* which the Wind is blowing.

Bws WIND ANGLE

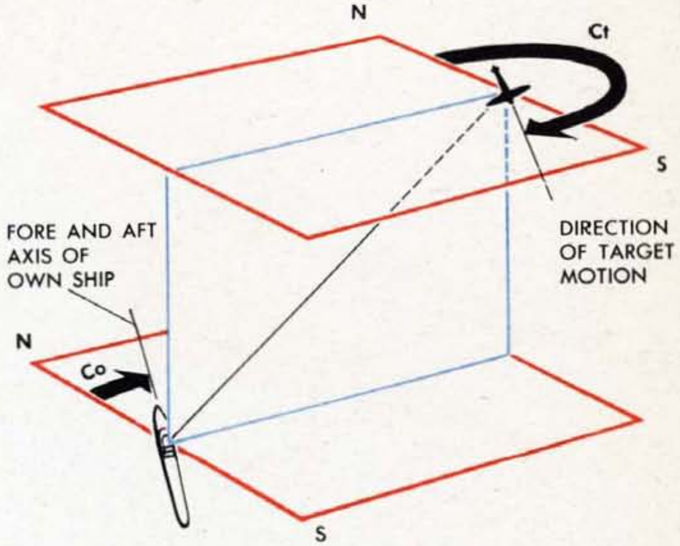
The angle between the direction *from* which the Wind is blowing and the vertical plane through the Line of Sight, measured in the horizontal plane clockwise from the direction from which the Wind is blowing.

Co SHIP COURSE

Compass heading of Own Ship.

Ct TARGET COURSE

Compass Direction toward which the Target is moving.



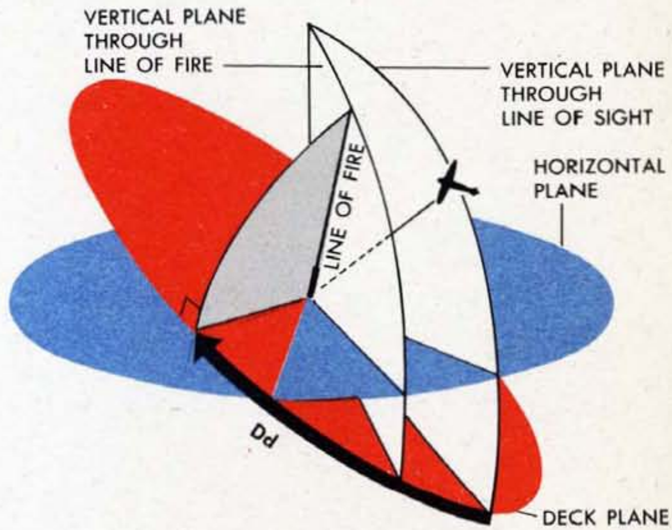
Dd DECK DEFLECTION

The angle representing total Deflection in the deck plane; it is added to Director Train to obtain Gun Train Order, $B'gr$.

$$Dd + B'r = B'gr \quad \text{and}$$
$$Dd = jDd + Dz$$

jDd PARTIAL DECK DEFLECTION

One term of a mechanism equation used in computing total Deck Deflection, Dd.

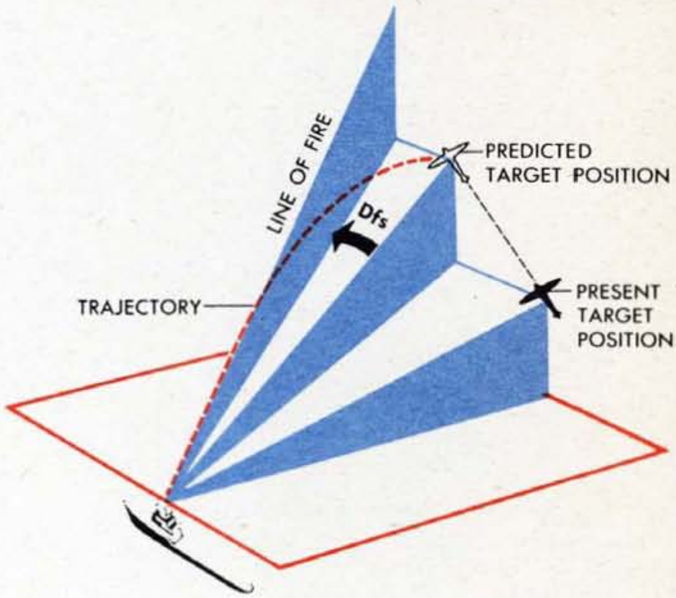


Dfs DRIFT CORRECTION

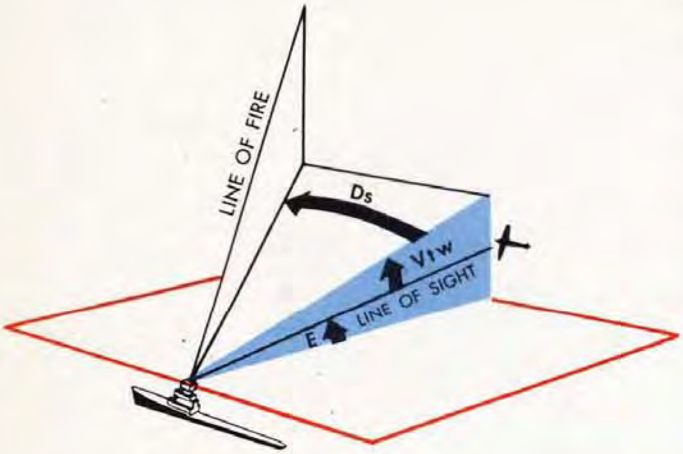
The lateral Deflection angle to compensate for drift of a projectile, measured in the slant plane through the Predicted Target Position.

$$Dfs = K\ (Vf + Pe + Vfm - K_1)$$

Dj DEFLECTION SPOT



NOTE:
The term "deck plane" does not mean the plane through the deck, but a plane at the level of the Director Sights parallel to the Director roller path.



Ds SIGHT DEFLECTION

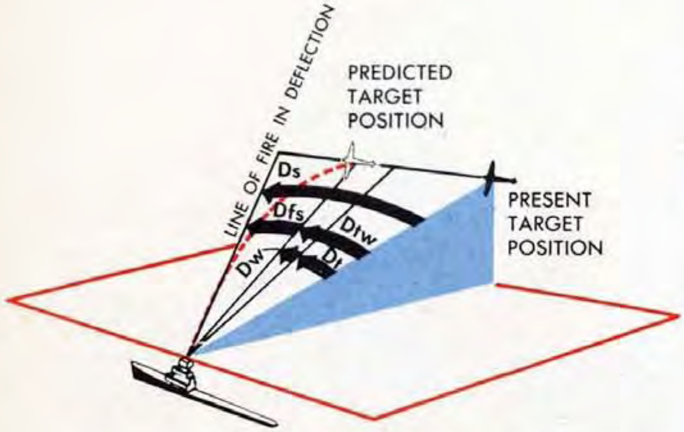
The angle between the vertical plane containing the Line of Sight and the vertical plane through the Line of Fire, measured in the plane at right angles to the vertical plane containing the Line of Sight, at angle *Vtw* above the Line of Sight. *Ds* is positive when the gun is trained to the right of the Line of Sight.

(This is an approximation of *Ds* as defined in OD 3447.)

$$Ds = Dtwj - Dfs$$

Dt RELATIVE MOTION DEFLECTION PREDICTION

Deflection Prediction to compensate for Relative Motion of Own Ship and Target during Time of Flight. (Does not exist separately in the mechanism.)



HERE Dt, Dw, Dtw, AND Ds ARE NEGATIVE

Dw WIND DEFLECTION PREDICTION

Deflection Prediction to compensate for the effect of Apparent Wind on the projectile. (Does not exist separately in the mechanism.)

Dtw RELATIVE MOTION AND WIND DEFLECTION PREDICTION

$$Dtw = Dt + Dw$$

Dtwj TOTAL DEFLECTION PREDICTION

$$Dtwj = Dtw + Dj$$

Dz

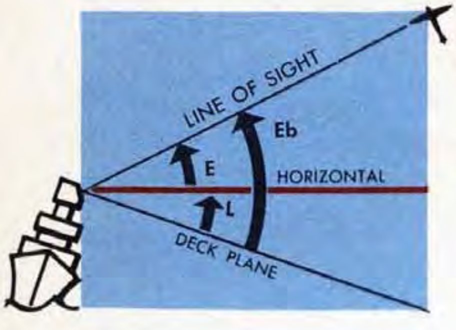
One term of a mechanism equation used in computing *Dd;* it represents approximately the Trunnion Tilt Train Correction to compensate for Cross-level.

$$Dz + jDd = Dd$$

E TARGET ELEVATION

The angle between the horizontal plane and the Line of Sight, measured in the vertical plane through the Line of Sight.

$$E = Eb - L$$



Eb DIRECTOR ELEVATION

The angle between the deck plane and the Line of Sight, measured in the vertical plane through the Line of Sight.

cE GENERATED TARGET ELEVATION

Target Elevation computed by the instrument.

△cE INCREMENT OF GENERATED TARGET ELEVATION

Changes of Target Elevation computed by the instrument.

△cEb INCREMENT OF GENERATED DIRECTOR ELEVATION

Changes of Director Elevation computed by the instrument.

$$\triangle cEb = \triangle cE + L$$

△cEb + Zd/30 ELEVATION CORRECTION

Computed Changes of Director Elevation compensated for the roll of the Director Sights in Cross-level.

dE ANGULAR ELEVATION RATE

(Does not exist separately in the mechanism.)

jE INITIAL OR CORRECTIVE SETTING OF GENERATED TARGET ELEVATION

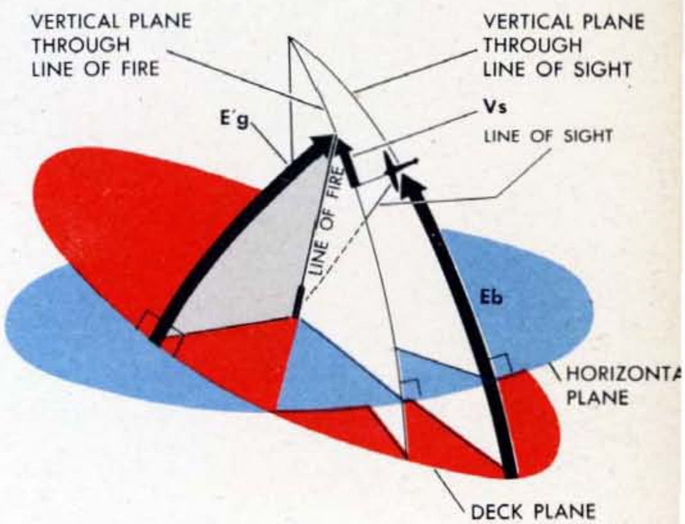
jEc LINEAR ELEVATION RATE CORRECTION

Rate Control Correction primarily affecting Linear Elevation Rate.

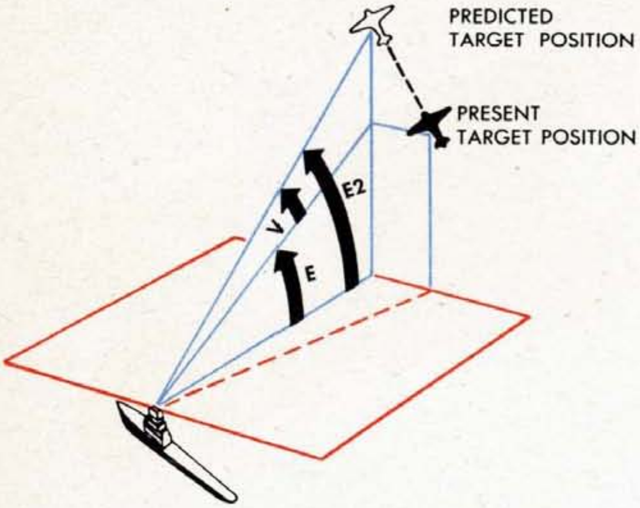
E'g GUN ELEVATION ORDER

Ordered Elevation of gun above the deck plane, measured in a plane through the Line of Fire and at right angles to the deck plane. Includes Parallax Correction for a vertical base, but not for a horizontal base.

$$E'g = Eb + Vs - Vz$$



Quick Reference Index

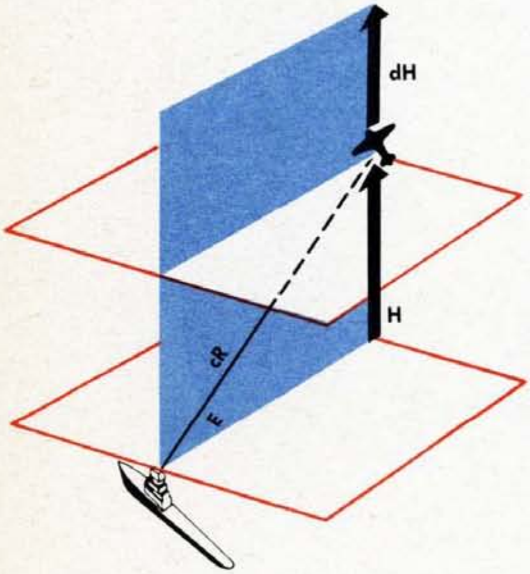


E2 PREDICTED TARGET ELEVATION

Approximate Elevation of the Target at the end of the Time of Flight.

$$E2 = E + V$$

F FUZE SETTING ORDER



H TARGET HEIGHT

Vertical distance between the Target and the horizontal plane through the Director sights.

$$H = cR \sin E$$

dH RATE OF CLIMB

Vertical component of Target Velocity.

jHc RATE OF CLIMB CORRECTION

Rate Control Correction primarily affecting Rate of Climb.

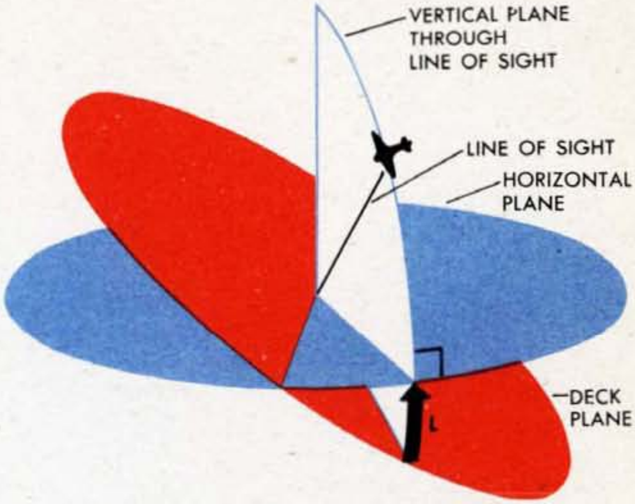
I. V. INITIAL VELOCITY OF PROJECTILE

K, K_1, K_2, etc. CONSTANTS

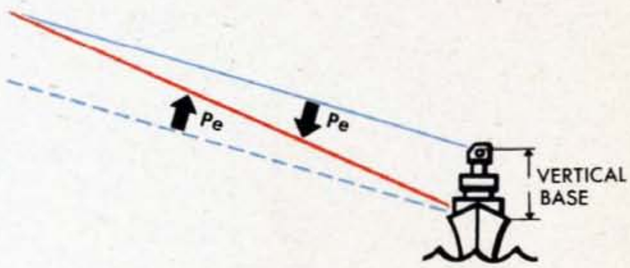
Two or more constants in the same expression are distinguished by numbers.

L LEVEL ANGLE

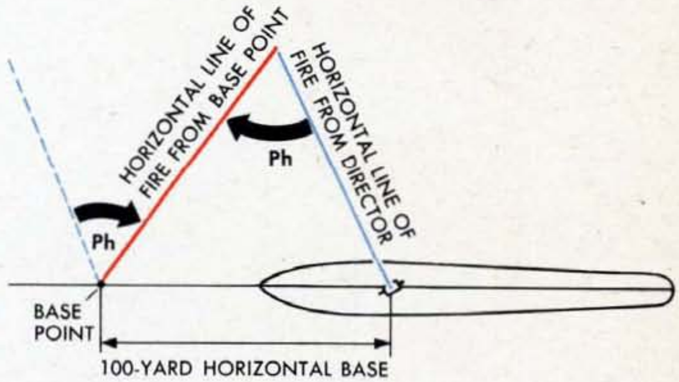
The angle between the horizontal plane and the deck plane, measured in the vertical plane through the Line of Sight. *L* is positive when the deck toward the Target is tilted down.



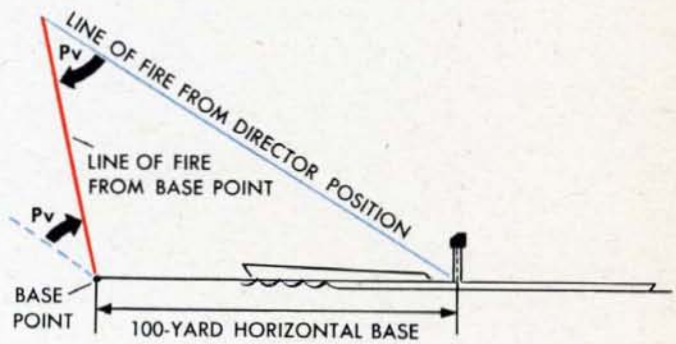
Pe ELEVATION PARALLAX CORRECTION FOR VERTICAL BASE



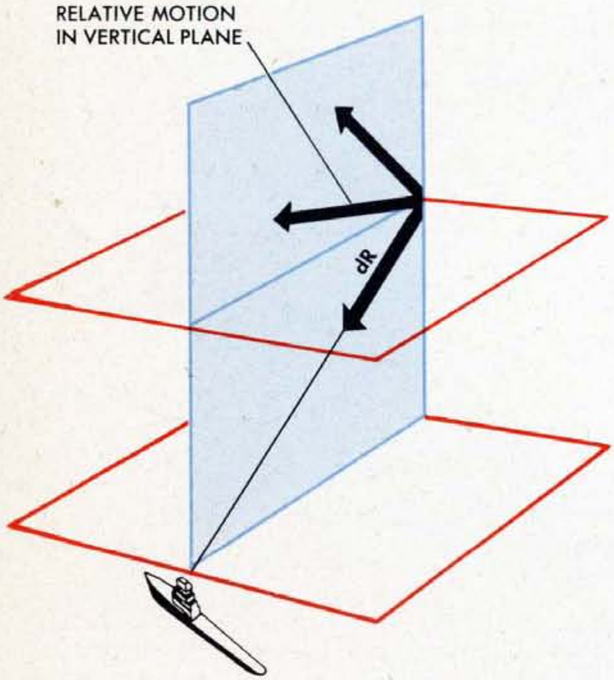
Ph TRAIN PARALLAX CORRECTION FOR HORIZONTAL BASE

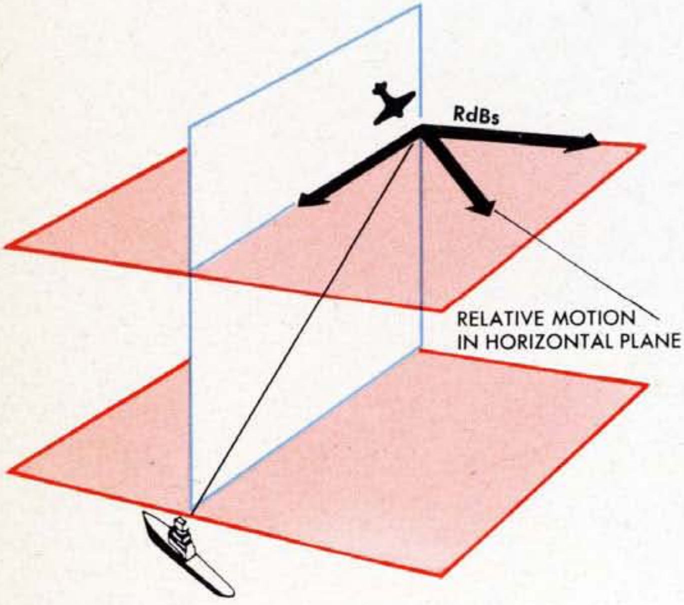


Pv ELEVATION PARALLAX CORRECTION FOR HORIZONTAL BASE



R OBSERVED PRESENT RANGE





cR GENERATED PRESENT RANGE

Present Range computed by the instrument.

1/cR RECIPROCAL OF GENERATED PRESENT RANGE

ΔcR INCREMENT OF GENERATED PRESENT RANGE

Changes of Range computed by the instrument. (Range Correction.)

dR DIRECT RANGE RATE

The Line of Sight component of relative motion between Target and Own Ship.

jdR DIRECT RANGE RATE CORRECTION

The Rate Control Correction primarily affecting Range Rate.

jR INITIAL OR CORRECTIVE SETTING OF GENERATED RANGE

jRc LINEAR RANGE CORRECTION

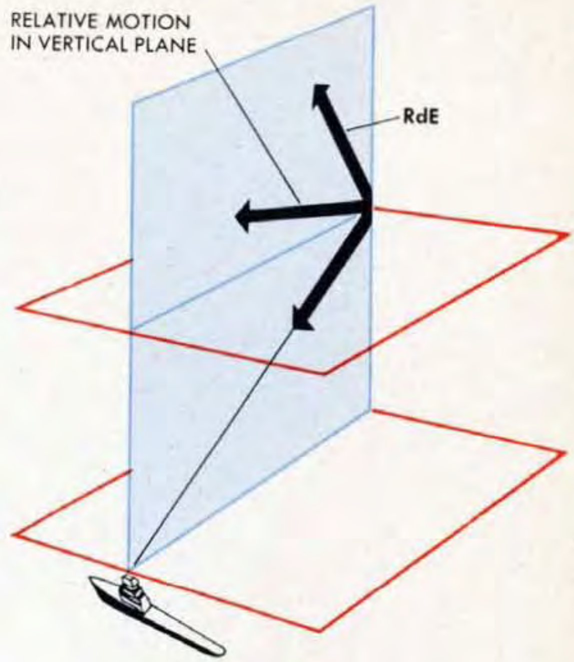
Applied to Generated Range.

RdBs LINEAR DEFLECTION RATE

The horizontal component of relative motion between Target and Own Ship, at right angles to the vertical plane through the Line of Sight.

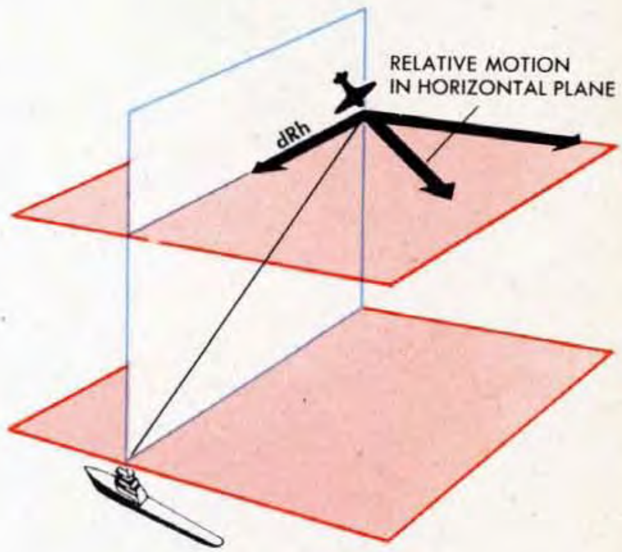
RdE LINEAR ELEVATION RATE

The component of relative motion between Target and Own Ship, at right angles to the Line of Sight and in the vertical plane through the Line of Sight.



dRh HORIZONTAL RANGE RATE

The horizontal component of relative motion between Target and Own Ship, in the vertical plane through the Line of Sight.



jdRh HORIZONTAL RANGE RATE CORRECTION

Rate Control Correction primarily affecting Horizontal Range Rate.

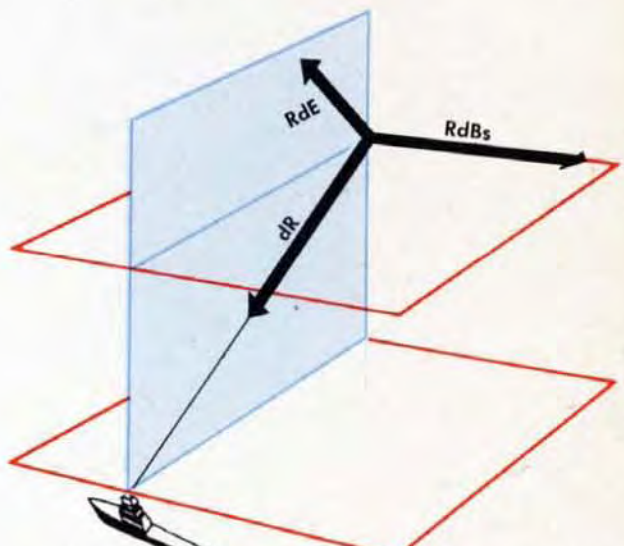
Rj RANGE SPOT

Rm

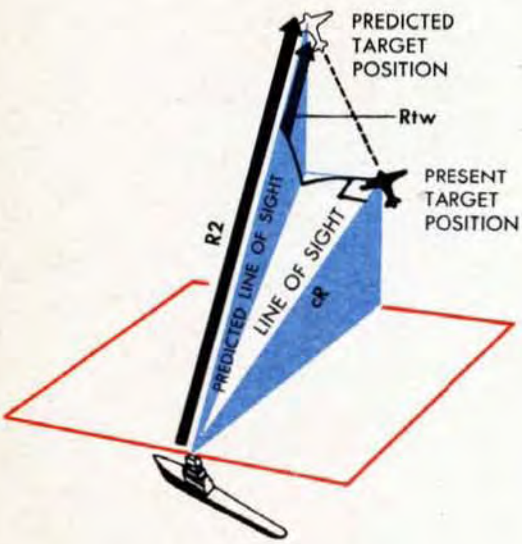
Correction to Range Prediction for a change in *I.V.* from 2550 f.s.

dRm

Alteration to Prediction Range Rate for a change in *I.V.* from 2550 f.s.



THE THREE RELATIVE MOTION RATES ARE USUALLY SHOWN LIKE THIS



dRs PREDICTION RANGE RATE

Direct Range Rate corrected for the effect of Deflection and Elevation Rates, and for a change in *I.V.* from 2550 f.s.

$$dRs = dR + dRxe + dRm$$

Rt RELATIVE MOTION RANGE PREDICTION

Compensates for the Relative Motion of Own Ship and Target during the Time of Flight. (Does not exist separately in the mechanism.)

Rw WIND RANGE PREDICTION

Compensates for the effect of Apparent Wind on the projectile. (Does not exist separately in the mechanism.)

Rtw RELATIVE MOTION AND WIND RANGE PREDICTION

(Does not exist separately in the mechanism.)

$$Rtw = Rt + Rw$$

Rtwm TOTAL RANGE PREDICTION

$$Rtwm = Rtw + Rm$$

dRxe RANGE RATE CORRECTION

Correction to Prediction Range Rate for the effect of the Deflection and Elevation Rates.

RTg

Correction in Fuze Range for Dead Time.

R2 ADVANCE RANGE (OR PREDICTED RANGE)

$$R2 = cR + Rtwm + Rj$$

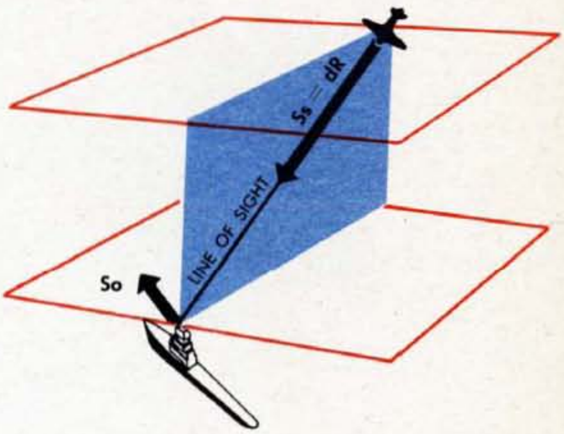
R3 FUZE RANGE

$$R3 = R2 + RTg$$

Sh TARGET SPEED

Horizontal ground speed of Target.

So OWN SHIP SPEED



Ss DIVING SPEED OF TARGET

Speed along the Line of Sight, or Direct Range Rate.

Sw TRUE WIND SPEED

T TIME

Generated by the regulated Time Motor.

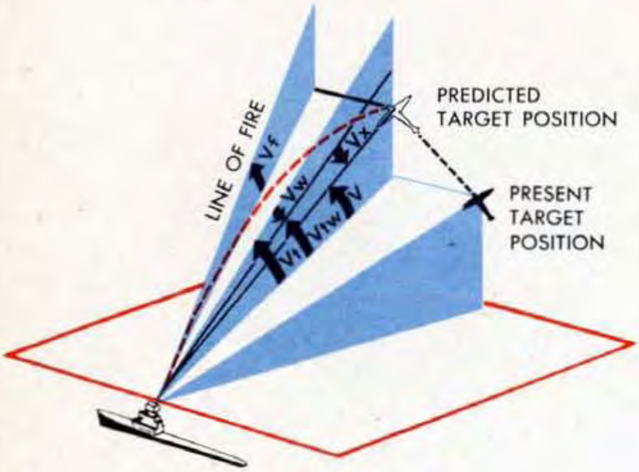
T/cR TIME DIVIDED BY GENERATED PRESENT RANGE

Tf TIME OF FLIGHT

Tf/R2 TIME OF FLIGHT DIVIDED BY ADVANCE RANGE

Tg DEAD TIME

Time in seconds between the setting of the fuze and the firing of the projectile.



V TOTAL ELEVATION PREDICTION

The approximate amount that Target Elevation changes during the Time of Flight.

$$V = Vtw - Vx + Vj$$

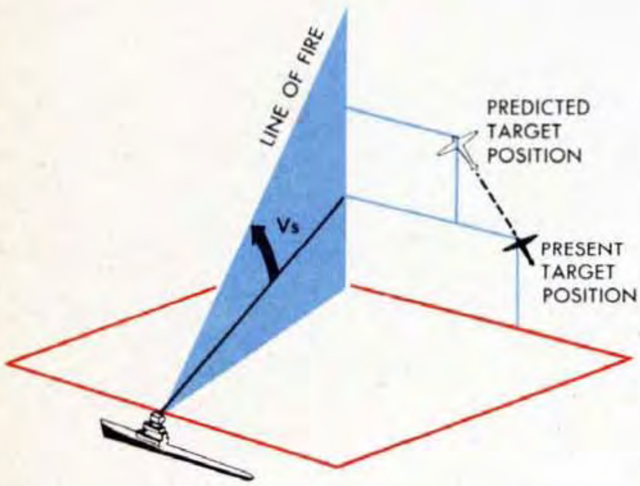
Vf SUPERELEVATION

The angle the gun must be elevated above the Predicted Line of Sight to compensate for the curvature of trajectory in the vertical plane.

Vfm

Correction to Superelevation for a change in *I.V.* from 2550 f.s.

Vj ELEVATION SPOT



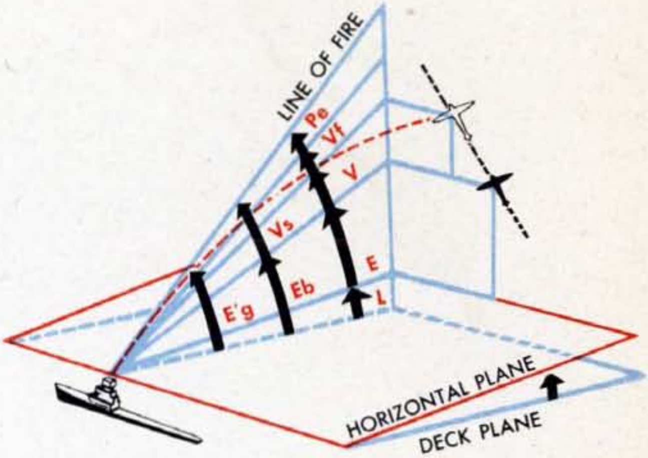
Vs SIGHT ANGLE

The difference between the elevation of the Line of Fire above the horizontal plane and the elevation of the Line of Sight above the horizontal plane, measured in the vertical plane through the Line of Fire. (Positive when the Line of Fire is above the Line of Sight.) (This is an approximation of Sight Angle as defined in OD 3447.)

$$Vs = V + (Vf + Pe) + Vfm$$

Vt RELATIVE MOTION ELEVATION PREDICTION

Compensates for the Relative Motion of Own Ship and Target during the Time of Flight. (Does not exist separately in the mechanism.)



A SUMMARY OF ELEVATION QUANTITIES

Vw WIND ELEVATION PREDICTION

Compensates for the effect of Apparent Wind on the projectile. (Does not exist separately in the mechanism.)

Vtw RELATIVE MOTION AND WIND ELEVATION PREDICTION

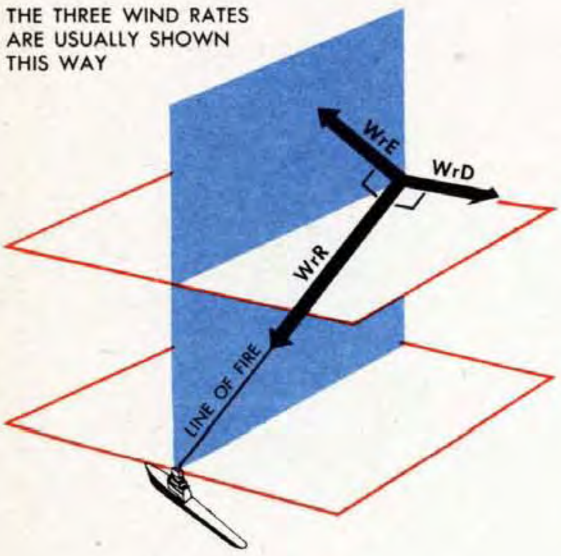
$$Vtw = Vt + Vw$$

Vx COMPLEMENTARY ERROR CORRECTION

Correction to Elevation Prediction to compensate for Deflection Prediction.

Vz TRUNNION TILT ELEVATION CORRECTION

Correction to Gun Elevation to compensate for the effect of Cross-level.



WrD DEFLECTION WIND RATE

The component of Apparent Wind Velocity affecting Deflection Prediction.

WrE ELEVATION WIND RATE

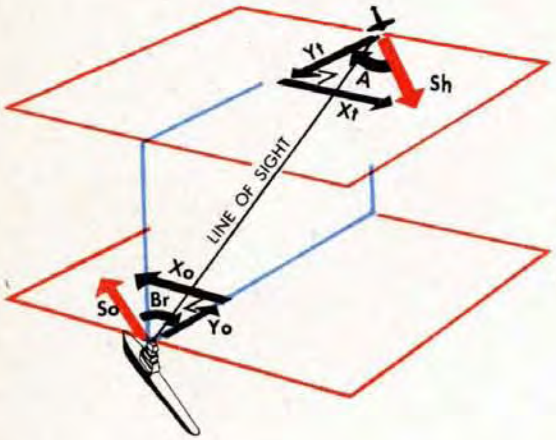
The component of Apparent Wind Velocity affecting Elevation Prediction.

$$WrE = Ywgr \sin K \cdot E2$$

WrR RANGE WIND RATE

The component of Apparent Wind Velocity affecting Range Prediction.

$$WrR = Ywgr \cos K \cdot E2$$



Xo

Horizontal component of Own Ship Velocity at right angles to the vertical plane through the Line of Sight. (Deflection component.)

$$Xo = So \sin Br$$

Xt

Horizontal component of Target Velocity at right angles to the vertical plane through the Line of Sight. (Deflection component.)

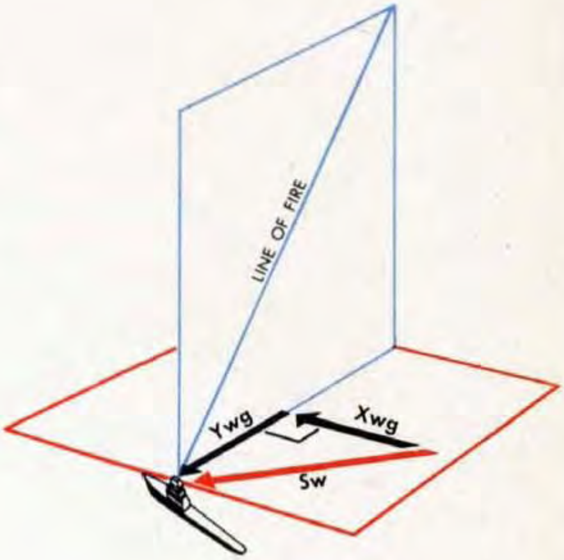
$$Xt = Sh \sin A$$

Quick Reference Index

Xwg

Horizontal component of True Wind Velocity, at right angles to the vertical plane through the Line of Fire. (Deflection component.)

$$Xwg = Sw \sin Bwg$$



Yo

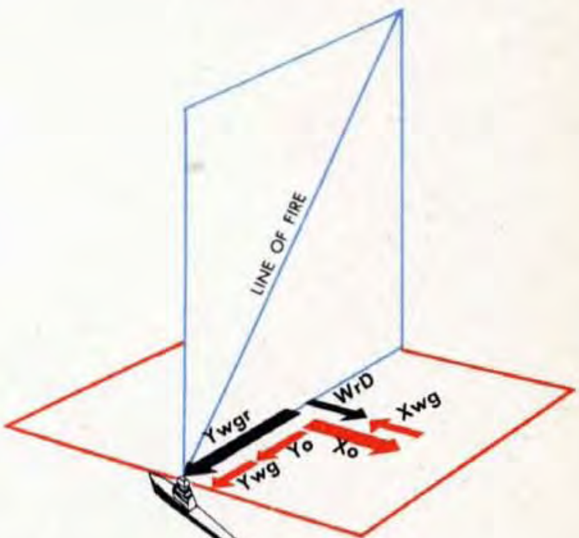
Horizontal component of Own Ship Velocity in the vertical plane through the Line of Sight. (Horizontal range component.)

$$Yo = So \cos Br$$

Yt

Horizontal component of Target Velocity in the vertical plane through the Line of Sight. (Horizontal range component.)

$$Yt = Sh \cos A$$



Ywg

Horizontal component of True Wind Velocity, in the vertical plane through the Line of Fire. (Horizontal range component.)

$$Ywg = Sw \cos Bwg$$

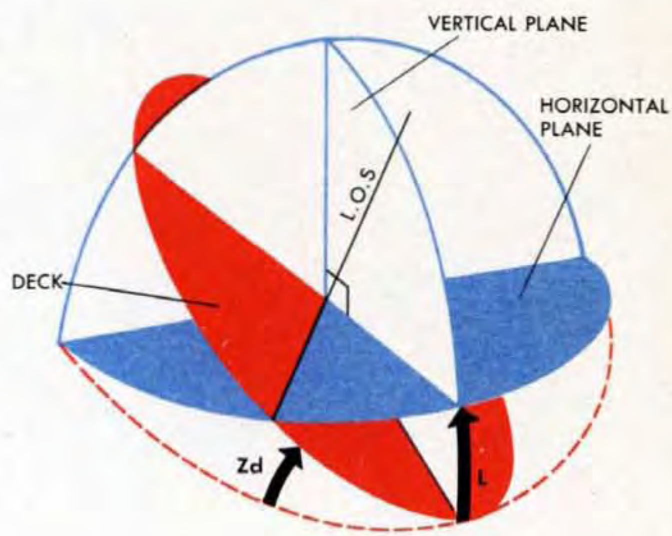
Ywgr

Horizontal component of Apparent Wind Velocity, in the vertical plane through the Line of Fire. (Horizontal range component.)

$$Ywgr = Yo + Ywg$$

Zd CROSS-LEVEL

The angle of roll of the deck about a line which is the intersection of the deck plane with the vertical plane through the Line of Sight. The correction for *Zd* is positive if, when one faces the Target, the deck at the left is tilted down.



ALPHABETICAL INDEX

C–(cont'd.)

F

G

H

M

N

O

O–(cont'd.)

P

T

T—(cont'd.)

V

W

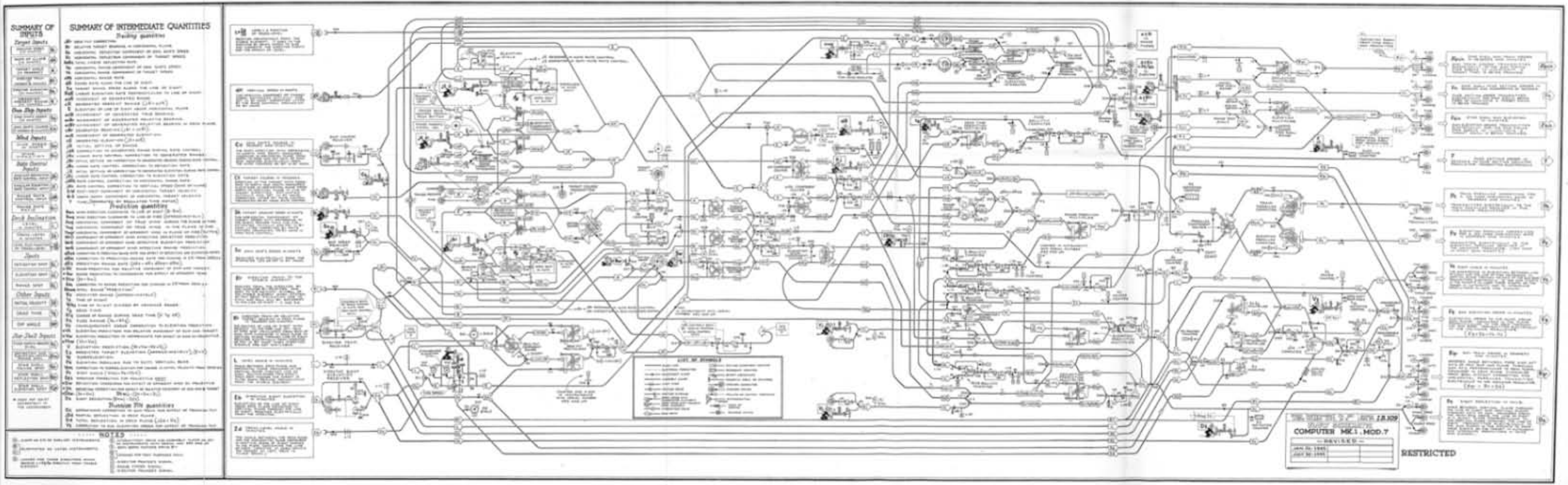
DISTRIBUTION

Requests for additional copies of OP 1064 should be submitted on NAVORD FORM 1, ORDNANCE PUBLICATIONS AND FORMS REQUISITION, to the nearest Ordnance Publications Distribution Center: Navy Yard, Wash. 25, D. C.; Adak, Alaska; Mare Island, Calif.; Pearl Harbor, T. H.; Guam Island, Marianas; Manus Island, Admiralty Islands. Distribution Center mailing addresses should be obtained from List 10 nn of the Standard Navy Distribution List, or from the reverse side of NAVORD FORM 1.

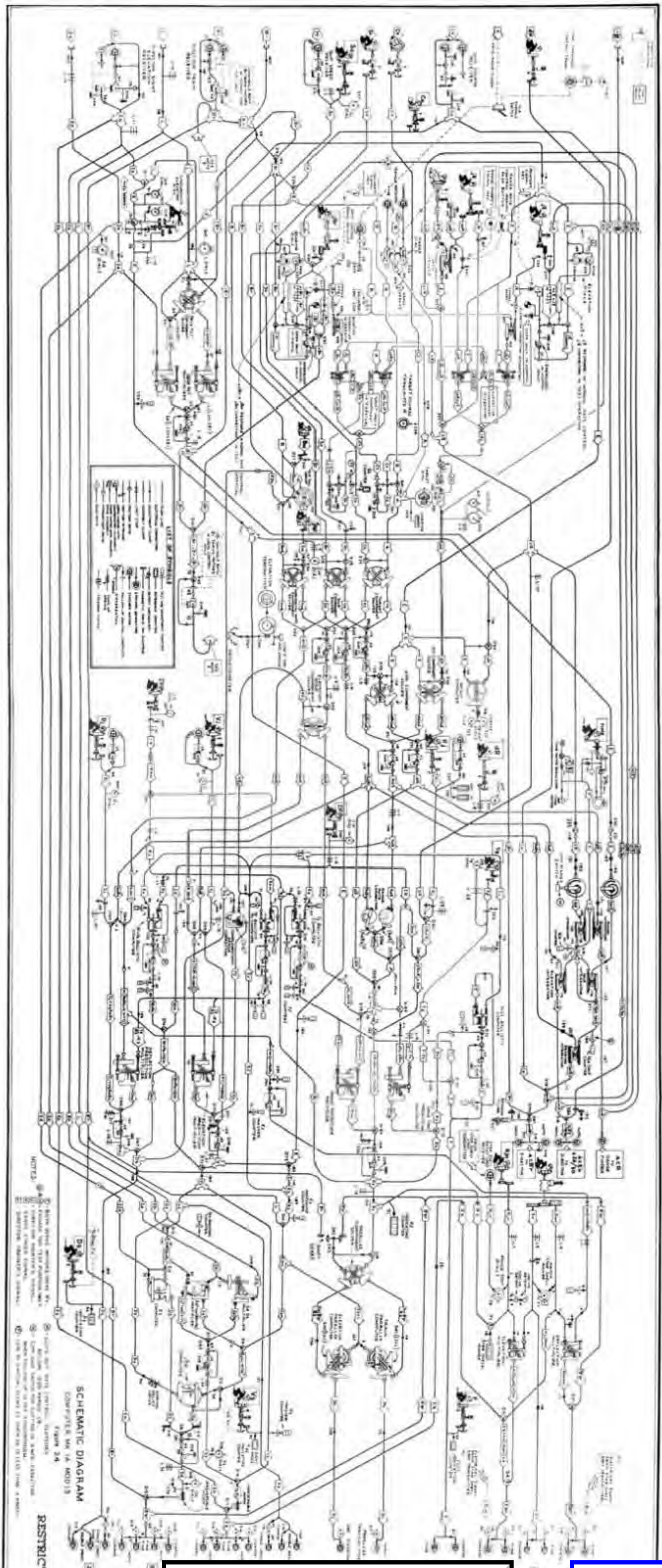
DISTRIBUTION:
Standard Navy Distribution List No. 28 (C) and 32 (R)
2 copies unless otherwise noted.

1.a, b, d, e, h, i, j, l; 2.f, k, r; 3.*, h, m, t, u, v, x, z, tt, vv, zz, ggg, lll, ooo, www, eeee; 3.* (5 copies), b, m; 5.b (London only); 6.a; 7.f, h, j, l; 7. (5 copies), b, c; 7. (10 copies), a; 8.n (SPECIAL LIST K, O,), x; 10.mm, qq, ss; 10. (25 copies), nn*; 11.a (CNO, Comdt Mar Corps); 12.a, b (Revision 1)*; 13.c(3), (4), (6); 14.a, b, i, q

*Applicable Addressees



SUMMARY OF INPUTS
Target Inputs
Own Ship Inputs
Wind Inputs
Rate Control Inputs
Deck Inclination
Spots
Other Inputs
Star Shell Inputs
SUMMARY OF INTERMEDIATE QUANTITIES
Tracking quantities
Prediction quantities
NOTES
LIST OF SYMBOLS
COMPUTER MK.1. MOD.7
REVISED
RESTRICTED


SCHEMATIC DIAGRAM
COMPUTER MK 1A MOD 13
Figure 34
RESTRICTED
LIST OF SYMBOLS
NOTES:

ADDENDUM NO.1

COMPUTER
MK 1A

Gene Slover's US Navy Pages | Table of Contents

This Page is Blank

CONTENTS

CONTENTS (Continued)

ILLUSTRATIONS

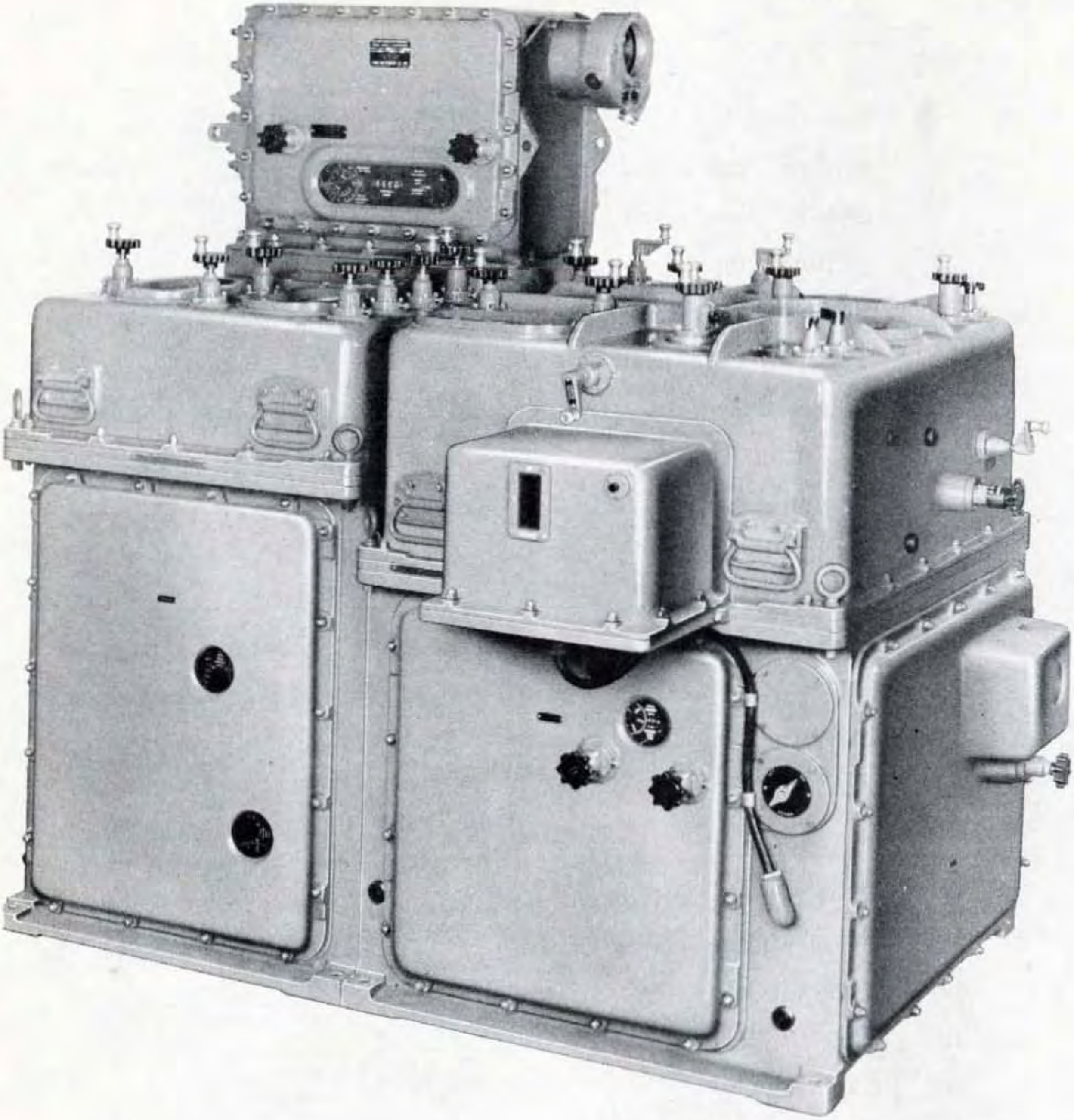


Figure 1. Computer Mk 1A and Star Shell Computer Mk 1.

COMPUTER MK 1A

INTRODUCTION

The purpose of this addendum is to bring OP 1064 "Computer Mk 1 and Mods — Description and Operation" up to date by describing the changes made in the computer since the publication date of OP 1064. All changes up to and including those authorized by NavOrd Ordalts 2331A, 2332, 2336, 2339, 2620, 2626, 2894, 2963, and 3091 are covered in this addendum. The changes authorized under the ordalts enumerated above are of such extent that after their performance on a Computer Mk 1, the designation of that instrument is changed to Computer Mk 1A. These changes modernize the instrument in the following respects:

1. Improve the anti-aircraft performance of the computer by replacing the North-South vector rate control mechanism of the Computer Mk 1 with a target vector rate control mechanism.

2. Double the limits of target speed and rate of climb.

3. Change the ballistic quantities used in all computers having 5"/38 cal. ballistics to correspond with revised 5"/38 cal. ballistic data contained in OP 551A, dated 11 February 1946.

4. Provide transmission of target elevation angle (E) from a potentiometer and from a synchro generator.

5. Provide computer control circuit changes which improve the operation of the instrument and reduce the task of the operating crew during rate control.

The major part of the description of Computer Mk 1 given in OP 1064 is applicable to Computer Mk 1A. Features wherein Computer Mk 1A differs from Computer Mk 1 as described in OP 1064 are treated in this addendum. Use of the addendum in conjunction with OP 1064 should therefore furnish an adequate description of Computer Mk 1A. For convenience in reference, arrangement of the material in the addendum parallels that in OP 1064. An index listing the pages in OP 1064 that do not accurately describe Computer Mk 1A, and specifying where the corrective information can be found in the addendum, is included at the back of the addendum.

GENERAL DESCRIPTION

All modifications of Computer Mk 1A (figure 1) are essentially the same in appearance, function, and operation. They differ mainly with respect to the self-contained ballistic data which adapt them to particular guns. The mod numbers vary according to the guns to be controlled as follows:

Mods 8, 12, 17, and 18	5"/54 cal.
Mods 13 and 19	5"/38 cal.
Mods 14 and 16	6"/47 cal.
Mod 15	8"/55 cal.

Mods 8 to 16 inclusive are covered in the addendum.

Mods 17 to 19 are in the design stage and sufficient information is not available for their inclusion. Mods 17 and 19 are to be used in Gun Fire Control System Mk 67 as follows:

a. Mod 17 in GFCS Mk 67 Mod 0, which has the usual 60 cycle synchro transmission system.

b. Mod 19 in GFCS Mk 67 Mod B, which provides for the use of 400 cycle supply in a large part of the synchro transmission system.

Computer Mk 1A differs from Computer Mk 1 in the following general respects:

1. The dials and gearing have been altered to make the limits of operation of the ship speed, target speed, rate of climb, and wind speed inputs of Computer Mk 1A twice the values of those in Computer Mk 1. Computer Mk 1A, therefore, can be operated effectively against modern aircraft.

2. The rate control mechanism is changed. It differs functionally; components of target motion are taken along and at right angles to the line of sight rather than with respect to a North-South axis. One of the principal mechanical differences is the elimination of the vector solver, which was made possible by the functional change. Another mechanical difference is the addition of a rate of climb (*dH*) follow-up. The sensitivity of the mechanism has been increased, or, stated another way, the time constant, which is the time required to reduce an error to 37% of its initial value, has been decreased. Greater flexibility of operation is obtained by the addition of the means whereby the time constant can be varied at the will of the operator.

3. A number of automatic operating controls have been added, resulting in more satisfactory operation of the gun fire control system as a whole, and in simplification of the task of the computer operating crew.

4. An additional *I.V.* correction is applied in the predictor section of Computer Mk 1A Mods 13, 14, 15, and 16 by means of an *I.V.* knob on the front of the computer.

5. Certain servo motor circuits have been modified to reduce oscillations in the fuze *(F)*, and gun elevation order *(E'g)* outputs.

6. The fuze computation network has been changed.

7. In Computer Mk 1A Mods 8 and 12, provision is made for obtaining superelevation for ranges beyond 20,000 yards in surface fire.

8. All mods of Computer Mk 1A transmit target elevation *(E)* in two ways: by synchro transmission, and through the output of a potentiometer.

9. Computer Mk 1A Mod 15 computes and transmits values of parallax range instead of parallax in elevation due to a horizontal base *(Pv)*.

All of these features are dealt with in detail later.

The content of this addendum is divided into three major sections corresponding to the three major sections of OP 1064 and having the same designations, viz., General Description, Operation, and Detailed Description. The General Description given in OP 1064 is applicable to Computer Mk 1A when modified as indicated in the General Description section of this addendum. The headings used in this section of the addendum correspond to those under which the same features are described in OP 1064, i.e., corresponding descriptions in the General Description sections of OP 1064 and the addendum appear under the same headings. This is not exactly true for the Operation and Detailed Description sections; but the system has been followed as closely as possible. Reference to the comparative index at the back of this addendum will help in correlating the material in the addendum with that in OP 1064.

Basic Mechanisms

In general, Computers Mk 1 and 1A contain the same types of basic mechanisms, but they do not contain the same number of each type. The principal difference is the elimination of the vector solver and the addition of a time delay relay (agastat).

Where basic mechanisms have been added or removed in converting a Mk 1 to a Mk 1A, the fact will be indicated in the pertinent descriptive material.

Types of Targets and Attack

Computer Mk 1A produces gun orders for combating the same types of targets and attack as does Computer Mk 1. However, it should be noted that Computer Mk 1A can be operated successfully against targets having twice the maximum horizontal and vertical speeds as Computer Mk 1. As an example, Computer Mk 1A computes gun orders for continuous fire against dive bombers attacking other ships when the vertical component of target speed is as much as −500 knots, in contrast to the previous maximum rate of −250 knots.

Automatic Fire Control in the Gun Director Mk 37 System

The description under this heading in OP 1064 (page 24) applies to Computer Mk 1A except for that portion given under item 4 "Correcting the target motion estimates".

When operating Computer Mk 1A it is unnecessary for the computer crew to apply estimates of target motion (either initial or corrective). Horizontal target speed *(Sh)* and rate of climb *(dH)* are automatically brought to zero when the computer time motor is stopped. As soon as the computer is engaged in the tracking problem (starting the time motor) target course *(Ct)* is slewed to the proper quadrant for tracking, and *Sh* and *dH* are brought to their computed values automatically. Thus, the proper values of target motion are established to produce accurate outputs of generated range, elevation, and bearing.

Tracking the Target

The description given under this heading in OP 1064 is entirely adequate for Computer Mk 1A with one exception. With reference to item 2 on page 29, it has already been stated that the computer crew need not apply estimates of target motion when in Automatic (Normal) control.

It should be noted that provision has been made in Computer Mk 1A for the increased speeds of targets. This was accomplished by doubling the values of the target speed, rate of climb, ship speed, wind speed, and related shaft lines in the Control Section, and changing the target diving speed, ship speed, wind speed, and rate of climb dials. A complete description of the changes involved is given in the Detailed Description section of this addendum.

The Rate Control Group

The description given under the heading "Rate Control Group" in OP 1064 (page 50) is applicable to Computer Mk 1A when modified by the statements given hereunder.

a. The function of the rate control group is to establish and correct the values of *Sh*, *dH*, and *A* applied in the computer.

b. In Local control, initial settings of target speed and course are determined from estimates of target motion. In Automatic control, however, estimates of target motion are not necessary.

c. In Computer Mk 1A the determination of relative motion rates, which is one of the major steps in the solution of the fire control problem, is made from known values of own ship motion and of target position, and from determined values of target motion. When the determined values of target motion are correct, the relative motion rates will also be correct. In Local control, target motion must be determined by progressively setting in estimates and correction of horizontal target speed *(Sh)*, and target angle *(A)*. In Automatic control, this process is carried on automatically. The process of establishing the correct values of target motion, either by estimate or mechanically, is termed "Rate Control".

d. The rate control computing mechanism of Computer Mk 1A consists of four

Table of Contents

component integrators, two disc integrators, and related gearing.

e. The rate control computing mechanism of Computer Mk 1A is used only in Automatic Control. The term "Normal Control" is used to designate Automatic control in Computer Mk 1A.

Automatic Rate Control. The description given on page 52 of OP 1064 for Automatic Rate Control is applicable to Computer Mk 1A, but the description on page 53 for Semi-Auto is not.

Putting in range rate control corrections. The description given under this heading in OP 1064 (pages 54 and 55) is applicable to Computer Mk 1A with the following exceptions.

In paragraph two of page 54 it is stated that range is received only intermittently. Computer Mk 1A receives continuous inputs of range whenever the radar equipment with which the gun fire control system is equipped is utilized for ranging.

With reference to the description under the heading "In Automatic Operation" it should be noted that Computer Mk 1A operates to bring *cR* into synchronism with *R* whenever the range rate control switch is at AUTO, independently of the operation of the rangefinder's signal key. However, the input of range will not affect operation of the range rate control computing mechanism unless the key is pressed.

The description under the sub-heading "In Semi-Automatic Operation" is misleading in that it implies that the mode of operation described is applicable only when the computer is set for Semi-Automatic control. In both Computer Mk 1 and Computer Mk 1A the mode of operation of the range rate control mechanism is controlled by one switch, the range rate control switch, while the mode of operation of the elevation and bearing rate control mechanism is controlled by another switch, designated the control switch. The computer is said to be in the type of control for which the control switch is set; but range rate control will be either automatic or manual for any type of computer control, depending entirely on the setting of the range rate control switch. In considering operation of Computer Mk 1A it should be borne in mind that there is no Semi-Automatic control, and that Automatic control is designated Normal control.

The range correction ratio changer. The description contained under the heading "The range correction integrator" in OP 1064 accurately describes this mechanism with the following exceptions. The range rate ratio knob of Computer Mk 1A is graduated from 0 to 16 rather than from 1 to 5. The new figures represent range time constants in seconds (the time required to reduce the error in range to 37% of its initial value), rather than purely arbitrary numbered positions as formerly. Throughout the description the term "range correction integrator" should be construed as meaning "range correction ratio changer" as the name of the mechanism has been changed to "the range correction ratio changer" in Computer Mk 1A. This more accurately designates the function of the mechanism, which is to provide a means of applying a variable ratio in the *jRc* input line, rather than performing integrations.

How Rate Control Corrects Rate of Climb, Target Speed, and Target Angle

For illustrations pertaining to this subject reference should be made to figures 9, 10, 11, and 24 of the addendum rather than to those given on pages 56 and 57 of OP 1064. Figure 24 is a flow schematic diagram which will be found at the end of the addendum.

The description contained in OP 1064 under this heading is correct in so far as the determination of the vertical target component correction *(jHc)* and the horizontal component of correction *(jdRh)* by the elevation component integrators is concerned. However, determination of the rate corrections to target speed and target angle differs in Computer Mk 1A from the description given in OP 1064. In this instrument, components of the horizontal rate corrections *jdRh* and *jBc* are applied directly to the target vector, rather than first being resolved

into North-South and East-West components. In consequence, the cumbersome target vector solver is eliminated. In order to apply *jdRh* and *jBc* directly to the target vector, target angle (rather than true bearing) is used to drive the vector gears of the *jdRh* and *jBc* component integrators. See figure 24.

Included in the rate control system of Computer Mk 1A are sensitivity units that establish the time taken for the system to reduce rate errors to values where the rates can be used for computing adequate gun orders. The time required for reducing a rate error to approximately 37% of its initial value is referred to as the time constant *(Tc)*. The time constant can be used as an indication of the system's sensitivity; the lower the value of *TC*, the quicker the system responds to changes in inputs. The rate control system of Computer Mk 1A is treated in detail in the Detailed Description section of this addendum.

Another Way to Think About Rate Control

The description contained under this heading in OP 1064 (page 58) is applicable to Computer Mk 1A if it is considered that the computer is in Local control.

The Rate Control Group Completes the Tracking Section

In the description under this heading in OP 1064, the last two paragraphs on page 61 are not applicable to Computer Mk 1A. In this instrument a faster solution of the rate control problem will be obtained by using the rate control computing mechanism, i.e., with the Computer in Automatic control.

Parallax Correction

The description under this heading (page 66 in OP 1064) is applicable to Computer Mk 1A except as follows. Mod 15 of the Computer Mk 1A does not compute elevation parallax due to horizontal base *(Pv)* as do all other mods. Instead, it computes parallax range, a partial computation, which it transmits to the guns where the computation of parallax is completed. The mechanism for computing parallax range occupies the space made available by the omission of the elevation parallax computer.

The Star Shell Computer

The various mods of Star Shell Computer Mk 1 used with Computer Mk 1A are listed here according to the mod of Computer Mk 1A with which they are used:

MOD OF COMPUTER MK 1A	MOD OF S.S. COMPUTER MK 1
13	0 and 1
8, 12	2
14, 16	3
17	4
19	6

OP 1064 (pages 107, and 356 to 367) adequately describes Star Shell Computer Mk 1 Mods 0, 1, 2. The description of Mods 1 and 2 is applicable to Mod 3, because Mod 3 is the same as these mods except for the extent of certain limits. Data for the description of Mods 4 and 6 are not available, as these mods are in the design stage.

Inputs and Outputs of the Computer Mk 1A

The inputs to Computer Mk 1A are the same as those for the Computer Mk 1 (see pages 70 and 71 of OP 1064). It should be noted, however, that for Computer Mk 1A, the target motion inputs *Sh, dH, A,* and *Ct* are as described in item 1 under the above heading in OP 1064 only during Local control. In Computer Mk 1A, these quantities are determined mechanically in the instrument during Normal control.

The outputs are the same except that Computer Mk 1A (all mods) has an additional output of target elevation *(E)*, and the Mod 15 has parallax range instead of *Pv* as an output.

Target elevation *(E)* is transmitted electrically from a potentiometer and from a synchro unit. The potentiometer supplies information to Indicator Mk 22 Mod 0 in Radar Equipment Mk 25 Mod 2 for use during target acquisition. The synchro signal is available for use in target practice analysis.

SUMMARY OF COMPUTER MK 1A DATA

Size

When shipped, the Computer Mk 1A is stripped of protruding components, such as handcranks, switches, etc. It is shipped in one, two, or four pieces. For use in shipping and handling, the overall dimensions of the separate pieces are given in figures 2, 3, and 4.

With Star Shell Computer Mk 1 in place, the overall height is approximately 63.4 inches. A clear height of 65 inches, measured from the base of the computer, is required for removal of the star shell computer.

Weight

The total weight of Computer Mk 1A is approximately 3150 pounds. Star Shell Computer Mk 1 weighs approximately 240 pounds. Weights of parts of Computer Mk 1A, when separated as indicated in figures 3 and 4, are indicated in these figures.

Power Supply

The power and synchro circuits of Computer Mk 1A require 115 volt, 60 cycle, A.C. supply. The requirements of these circuits are tabulated below. The figures given for the power circuit represent the peak requirements for operating all servo motors of the computer. The figures given for the synchro circuit represent the peak requirement for excitation of the synchros in the computer only. Normal operating power for this circuit will be somewhat higher.

CIRCUITS ENERGIZED	WATTS	VOLTS	AMPS	POWER FACTOR
Power	1060	113	9.4	1.0
Synchro	496	108	42.8	.11

Limits of Operation

The limits of operation of Computer Mk 1A are given in the following tables. They differ in many instances from those for Computer Mk 1.

LIMITS OF OPERATION

INTERMITTENT DRIVES

SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
Ds	320 Mils	680 Mils	13
	390 Mils	590 Mils	15
Vs	2000′	3800′	13
	2000′	4460′	15
R2	1500 Yards	18,900 Yards	8, 12, 14, 15, 16
E2	0°	90°	ALL
cR	750 Yards	22,500 Yards	ALL
E	−2°	+85°	ALL
Eb + *Vs*	1640′	7160′	ALL
dRs	−900 Knots	+900 Knots	ALL

Note: Only the mods listed for a particular quantity are provided with an intermittent drive for that quantity.

Table of Contents

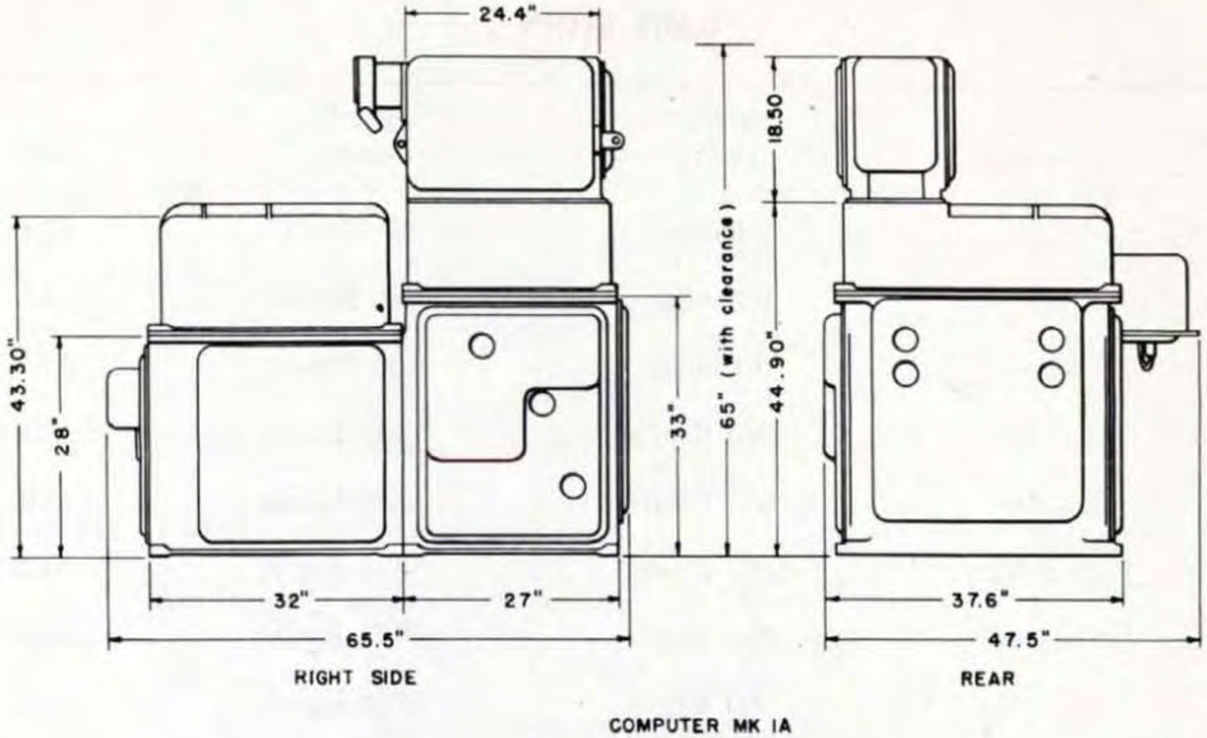


Figure 2. Outline Dimensions (One Piece).

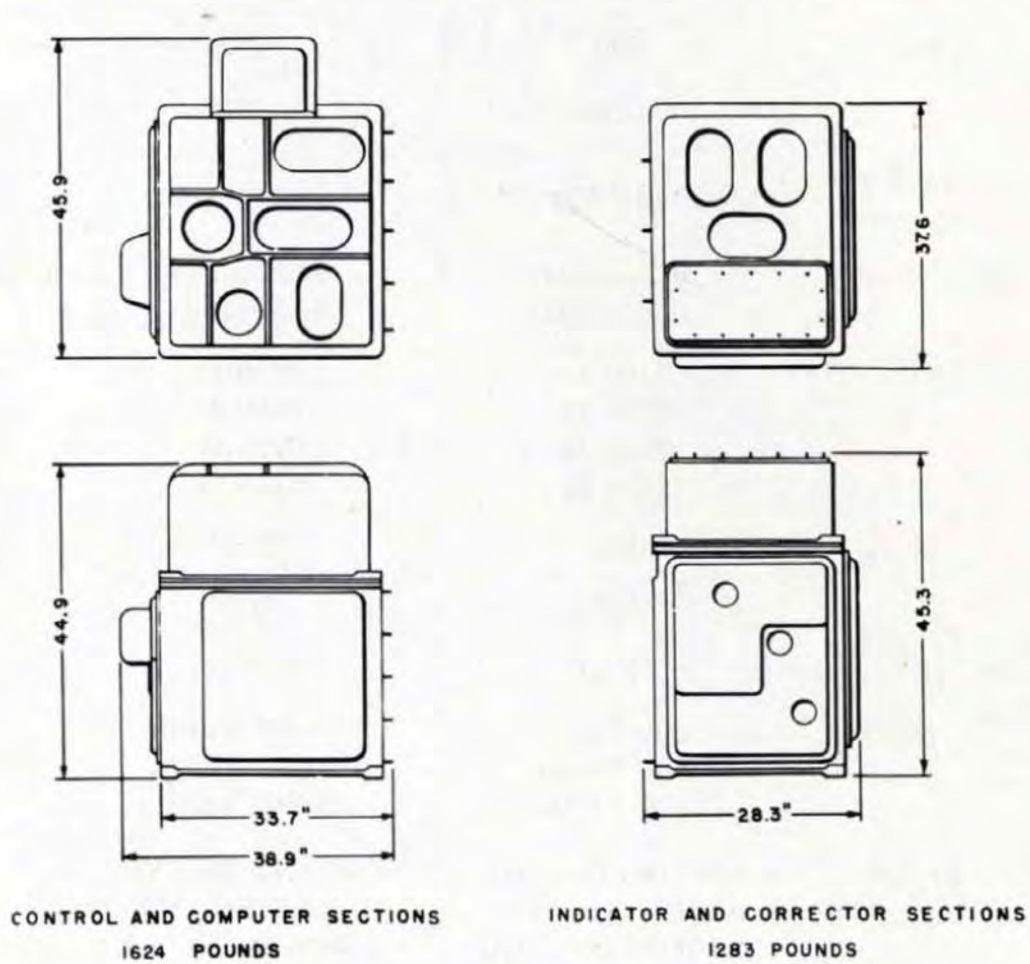


Figure 3. Outline Dimensions and Weights (Two Pieces).

LIMIT STOPS

STOP NO.	SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
L-1	*So*	0 Knots	90 Knots	ALL
L-2	*Sh*	0 Knots	800 Knots	ALL
L-3	*Sw*	0 Knots	120 Knots	ALL
L-4	*dH*	—500 Knots	+300 Knots	ALL
L-5	*dRh*	—880 Knots	+880 Knots	ALL
L-6	*RdBs*	—800 Knots	+800 Knots	ALL
L-7	*RdE*	—800 Knots	+800 Knots	ALL
L-8	*dR*	—900 Knots	+900 Knots	ALL
L-9	*Ywgr*	—200 Knots	+200 Knots	ALL
L-10	*cR*	0 Yards	35,000 Yards	ALL
L-11	*Eb*	500′	8600′	ALL
L-12	*E*	—25°	+85°	ALL
L-13	*Range Time Constant*	1 Second (Approx.)	16 Seconds	ALL
L-14	$Tg + F - Tf$	0 Seconds 0 Seconds	50 Seconds 49 Seconds	8, 12, 13, 14, 16 15
L-15	*I.V.*	2400 fs 2350 fs 2250 fs 2400 fs	2650 fs 2600 fs 2720 fs 2700 fs	8, 12 13 14, 16 15
L-16	*L*	480′	3520′	ALL
L-17	*Zd*	480′	3520′	ALL
L-18	*jB'r*	11°40′	348°20′	ALL
L-19	*R2*	500 Yards 500 Yards 500 Yards	18,000 Yards 20,000 Yards 20,200 Yards	13 8, 12, 15 14, 16
L-20	*Tf/R2*	0.001184 Sec./Yd. 0.00122 Sec./Yd. 0.001185 Sec./Yd. 0.001150 Sec./Yd.	0.002674 Sec./Yd. 0.00336 Sec./Yd. 0.002600 Sec./Yd. 0.002300 Sec./Yd.	8, 12 13 14, 16 15

LIMIT STOPS *(continued)*

STOP NO.	SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
L-21	*R2*	*300 Yards	*20,200 Yards	8, 12
	R2m	*300 Yards	*18,200 Yards	13
	R2m	*300 Yards	*20,400 Yards	14, 16
	R2m	*300 Yards	*20,200 Yards	15
L-22	$Vf + Pe$	0′	1800′	8, 12
		0′	2500′	13
		0′	1600′	14, 16
		0′	1250′	15
L-23	*R2*	*300 Yards	*20,200 Yards	8, 12, 15
		*300 Yards	*18,200 Yards	13
		*300 Yards	*20,400 Yards	14, 16
L-24	*Tf*	0.6 Seconds	50.6 Seconds	8, 12, 14, 15, 16
			60.6 Seconds	13
L-25	*R2*	*300 Yards	*20,200 Yards	8, 12, 15
		*300 Yards	*18,200 Yards	13
		*300 Yards	*20,400 Yards	14, 16
L-28	*Dtwj*	−518 Mils	+518 Mils	ALL
L-29	*Rj*	IN 12,000 Yards	OUT 1800 Yards	ALL
L-30	*Dj*	LEFT 180 Mils	RIGHT 180 Mils	ALL
L-31	*Vj*	DOWN 180 Mils	UP 180 Mils	13, 14, 15, 16
		DOWN 180 Mils	UP 342.5 Mils (24,600 Yards)	8, 12
L-32	*Dd*	−120°	+120°	ALL
L-34	*Vz*	−2940′	+1860′	ALL
L-35	*F*	0.6 Seconds	49.0 Seconds	8, 12, 14, 15, 16
		0.6 Seconds	55.0 Seconds	13
L-37	*V*	200′	3800′	ALL
L-38	*Tg*	0 Seconds	6 Seconds	ALL
L-39	*I.V.*	2350 fs	2600 fs	13
		2250 fs	2720 fs	14, 16
		2400 fs	2700 fs	15

*Limit cannot be reached when ballistic unit containing limit stop is installed in computer.

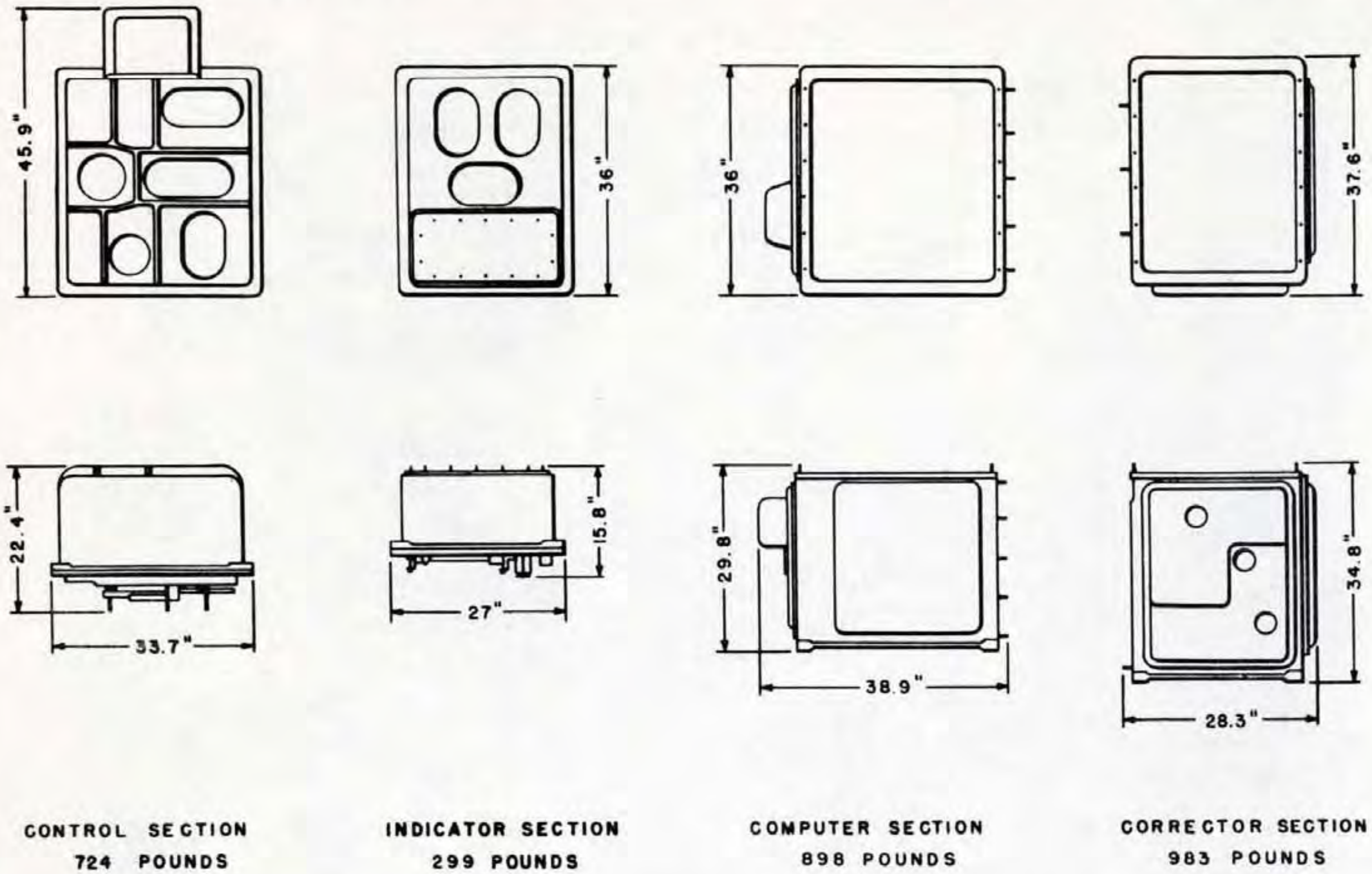


Figure 4. Outline Dimensions and Weights (Four Pieces).

STAR SHELL COMPUTER MK 1

STOP NO.	SYMBOL	LOWER LIMIT	UPPER LIMIT	MOD
L-1	$WrD + KRdBs$	—60 Knots (Read as 940 Knots on counter)	+60 Knots	ALL
L-2	Rjn	IN 2857 Yards	OUT 1500 Yards	0, 1
		IN 2700 Yards	OUT 1500 Yards	2, 3
L-3	Fn	8.20 Seconds	41.55 Seconds	0, 1
		9.70 Seconds	46.70 Seconds	2
		8.10 Seconds	46.02 Seconds	3
L-4	$jDwn$	4000 Yards	15,000 Yards	0, 1
		8000 Yards	19,500 Yards	2
		7000 Yards	20,000 Yards	3

SYNCHROS IN THE COMPUTER MK 1A

NAME		LOCATION SECTION	COVER	VALUE PER REV.	SIZE	MOD
Range Correction Transmitter		Control	1	1000 Yards	5G	ALL
Range Receiver	Coarse	Control	1	72,000 Yards	5F	ALL
	Fine	Control	1	2000 Yards	5F	ALL
Rate Control Range Receiver		Control	1	72,000 Yards	1F	ALL
Time Constant Control Transmitter		Control	1		1G	ALL
Target Course Transmitter		Control	1	360°	5G	ALL
Bearing Correction Ind. Transmitter		Computer	3	10°	5G	ALL
Bearing Correction Auto. Transmitter		Computer	3	5°	6G	ALL
Elevation Correction Ind. Transmitter		Computer	3	10°	5G	ALL
Elevation Correction Auto. Transmitter		Computer	3	5°	6G	ALL
Elevation Transmitter		Computer	5	180°	5G	ALL
		Computer	5	40 Ohms/Deg	POT	ALL
Ship Course Receiver	Coarse	Computer	5	360°	5B	ALL
	Fine	Computer	5	10°	5F	ALL
Deflection Spot Receiver		Indicator	2	360 Mils	5B	ALL
Elevation Spot Receiver		Indicator	2	360 Mils	5B	ALL
Range-Spot Receiver		Indicator	2	4000 Yards	5B	ALL
Ship Speed Receiver		Indicator	2	40 Knots	5B	ALL
Fuze Setting Order	Coarse	Indicator	2	100 Sec.	7G	8, 12, 13, 14, 16
	Coarse	Indicator	2	360/7 Sec.	7G	15
	Fine	Indicator	2	2 Sec.	7G	8, 12, 13, 14, 16
	Fine	Indicator	2	20/7 Sec.	7G	15

SYNCHROS IN THE COMPUTER MK 1A *(continued)*

NAME		LOCATION SECTION	COVER	VALUE PER REV.	SIZE	MOD
Single Speed Sight Angle Transmitter		Indicator	2	2400 Min.	6G	13
Double Speed Sight Angle Transmitter	Coarse	Indicator	2	7200 Min.	6G	13
	Coarse	Indicator	2	7200 Min.	7G	8, 12, 14, 16
	Coarse	Indicator	2	3600 Min.	7G	15
	Fine	Indicator	2	200 Min.	6G	13
	Fine	Indicator	2	200 Min.	7G	8, 12, 14, 16
	Fine	Indicator	2	100 Min.	7G	15
Single Speed Sight Deflection Trans.		Indicator	2	442.23 Mils	6G	13
		Indicator	2	210.48 Mils	7G	15
Double Speed Sight Deflection Trans.	Coarse	Indicator	2	4000 Mils	6G	8, 12, 14, 16
	Coarse	Indicator	2	4000 Mils	7G	13
	Fine	Indicator	2	100 Mils	6G	13
	Fine	Indicator	2	100 Mils	7G	8, 12, 14, 16
Gun Train Order Ind. Transmitter	Coarse	Corrector	8	360°	7G	ALL
	Fine	Corrector	8	10°	7G	ALL
Gun Train Order Auto. Transmitter	Coarse	Corrector	8	360°	7G	ALL
	Fine	Corrector	8	10°	7G	ALL
Gun Train Order Information Trans.		Corrector	8	10°	7G	14, 15, 16
Director Train Receiver	Coarse	Corrector	8	360°	5B	ALL
	Fine	Corrector	8	10°	5F	ALL

RESTRICTED

Table of Contents

SYNCHROS IN THE COMPUTER MK 1A *(continued)*

NAME		LOCATION SECTION	LOCATION COVER	VALUE PER REV.	SIZE	MOD
Gun Elevation Order Ind. Trans.	Coarse	Corrector	6	10,800 Min.	7G	ALL
	Fine	Corrector	6	600 Min.	7G	ALL
Gun Elevation Order Auto. Trans.	Coarse	Corrector	6	10,800 Min.	7G	ALL
	Fine	Corrector	6	600 Min.	7G	ALL
Director Sight Elevation	Coarse	Corrector	6	180°	5B	ALL
	Fine	Corrector	6	10°	5F	ALL
Train Parallax Transmitter		Corrector	6	30°/100 Yards	7G	ALL
Elevation Parallax Transmitter		Corrector	6	10°/100 Yards	7G	8, 12, 13, 14, 16
Parallax Range Transmitter		Corrector	6	.001 Rad./Yard	7G	15
Star Shell Gun Elev. Order Trans.	Coarse	Star Shell		10,800 Min.	6DG	0, 1
	Coarse	Star Shell		10,800 Min.	6G	2
	Fine	Star Shell		600 Min.	6DG	0, 1
	Fine	Star Shell		600 Min.	6G	2
Star Shell Fuze Setting Order Trans.	Coarse	Star Shell		100 Sec.	6G	0, 1, 2
	Fine	Star Shell		2 Sec.	6G	3
Star Shell Gun Train Order Trans.	Coarse	Star Shell		360°	6DG	0, 1
	Coarse	Star Shell		360°	6G	2
	Fine	Star Shell		10°	6DG	0, 1
	Fine	Star Shell		10°	6G	2
Star Shell Range Spot Receiver		Star Shell		4000 Yards	1F	0, 1

Design Features

All design features given under this heading in OP 1064 are applicable to Computer Mk 1A except that pertaining to initial velocity (*I.V.*). The design *I.V.* of Computers Mk 1A varies with the mod, as follows:

Mods 8, 12, 17, and 18	2550 fs
Mod 13	2500 fs
Mods 14 and 16	2565 fs
Mod 15	2600 fs
Mod 19	2500 fs

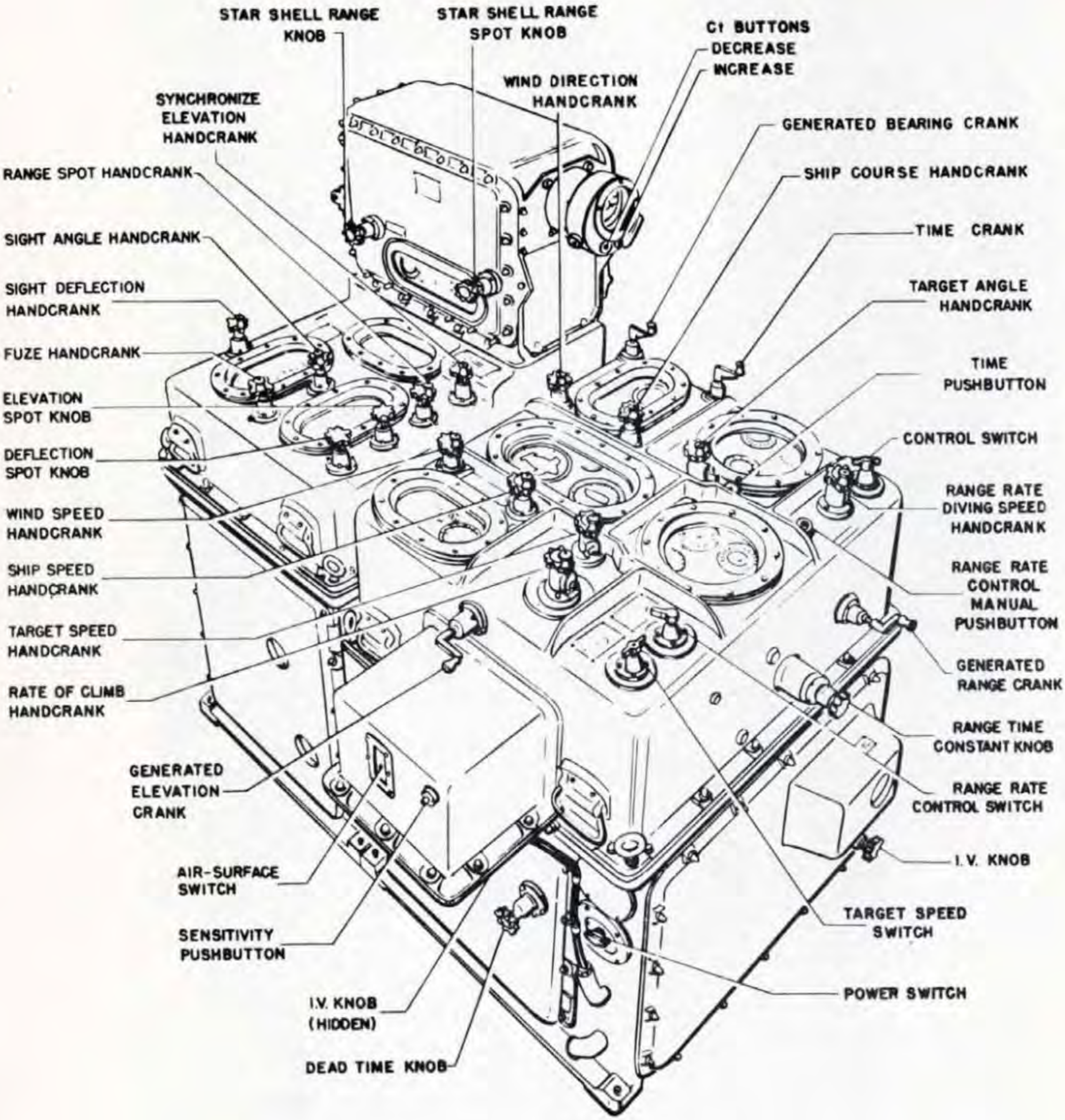


Figure 5. Computer Mk 1A — Operating Controls.

OPERATION

OPERATING CONTROLS

The arrangement of dials, handcranks, and switches of Computer Mk 1A is the same as that of Computer Mk 1, with the following exceptions:

1. The rate of climb handcrank has been relocated. The radar range receiver has been removed, and the rate of climb handcrank is located in the cover opening previously occupied by the radar range receiver window.
2. The time motor switch has been removed, and a time motor push button installed adjacent to the target speed dial group.
3. A sensitivity push button and an air-surface selector switch have been added at the elevation station.

Note: The locations of the operating controls mentioned in items 1, 2, and 3 are indicated in figure 5.

4. Three vernier dials have been added to increase the accuracy with which test problems can be set up. These are for range (*R*), target angle (*A*), and rate of climb (*dH*).

Operating dials and counters are the same as those on Computer Mk 1, except that some can indicate double their former values in order to permit tracking of targets having greater speeds.

The Dials on the Front of Computer Mk 1A

The Target and Ship Dial Group. The target and ship dial group (see figure 6) has been altered as follows:

1. The target dial gearing is equipped with a vernier dial that indicates target angle in tenths of a degree. The vernier dial is primarily for test purposes.
2. The wind speed dial is graduated from 0 to 120 knots.
3. The ship speed dial is graduated only from 0 to 50 knots, but can make a complete revolution, representing 90 knots.

The Target Speed Dial Group. This group is shown in figure 7. The target speed counter shows horizontal ground speed of the target (*Sh*) in knots, from 0 to 800 knots.

The rate of climb dials show rate of climb (*dH*) in knots. The coarse dial is graduated every ten knots from DIVE 500 knots through 0 to CLIMB 300 knots. A fine dial graduated every five knots, but unnumbered, has been added in Computer Mk 1A. When reading intermediate values on the fine dial, note should be taken of the fact that it turns in a direction opposite to that of the coarse dial.

The target speed diving dial shows diving speed (*Ss*). The dial is capable of rotating from 0 to ± 900 knots. However, since its primary purpose is to indicate diving speed (negative range rate), only the DIVE (minus) part is graduated and numbered. The graduations are at 20-knot intervals.

The Range Dial Group. The range dial group is the same as that of Computer Mk 1 except that the radar range dial and receiver are not included in the Mk 1A.

The range gearing of Computer Mk 1A is equipped with a vernier range dial. The vernier dial is located behind the threaded plug located in the side of the cover just below the range receiver dials. By means of the vernier, which has graduations at 5-yard intervals, range can be read or set to the nearest yard during test procedures.

Time Motor and Power Switches

A push button, located at the range station, has been substituted for the time mo-

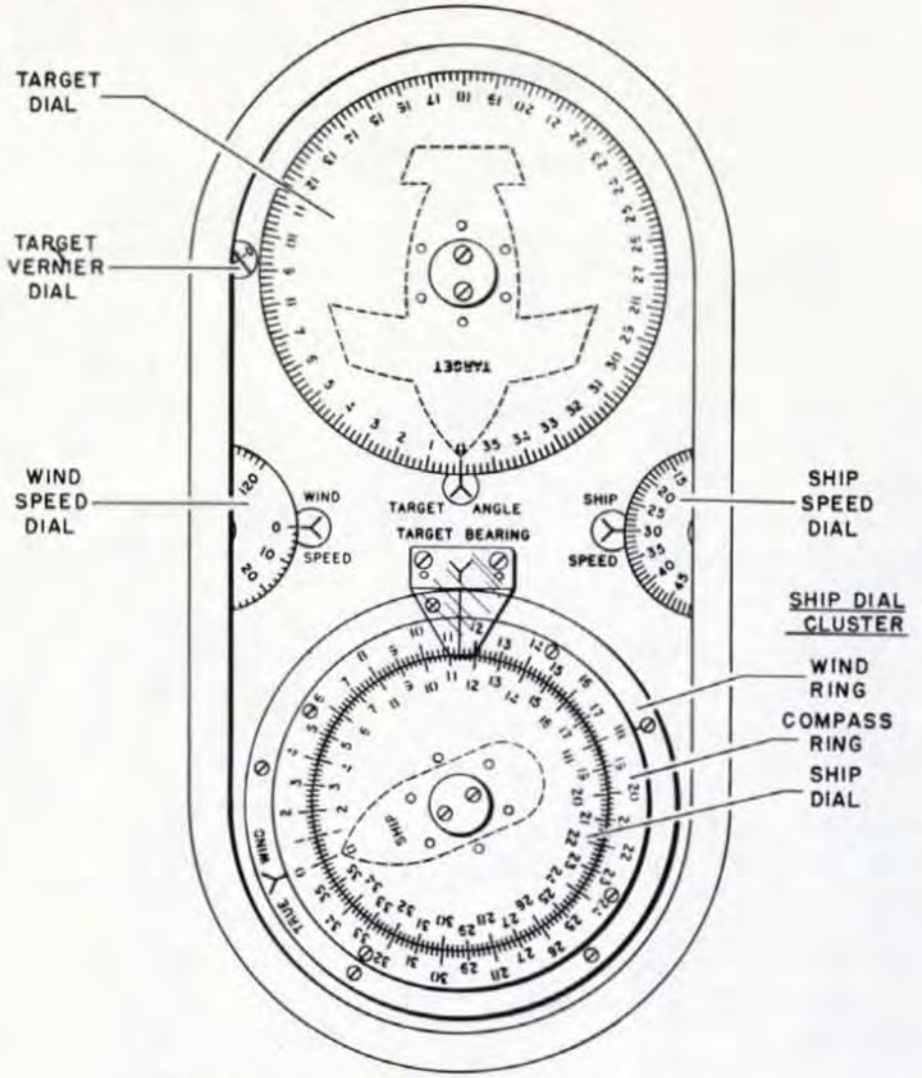


Figure 6. Target and Ship Dial Group.

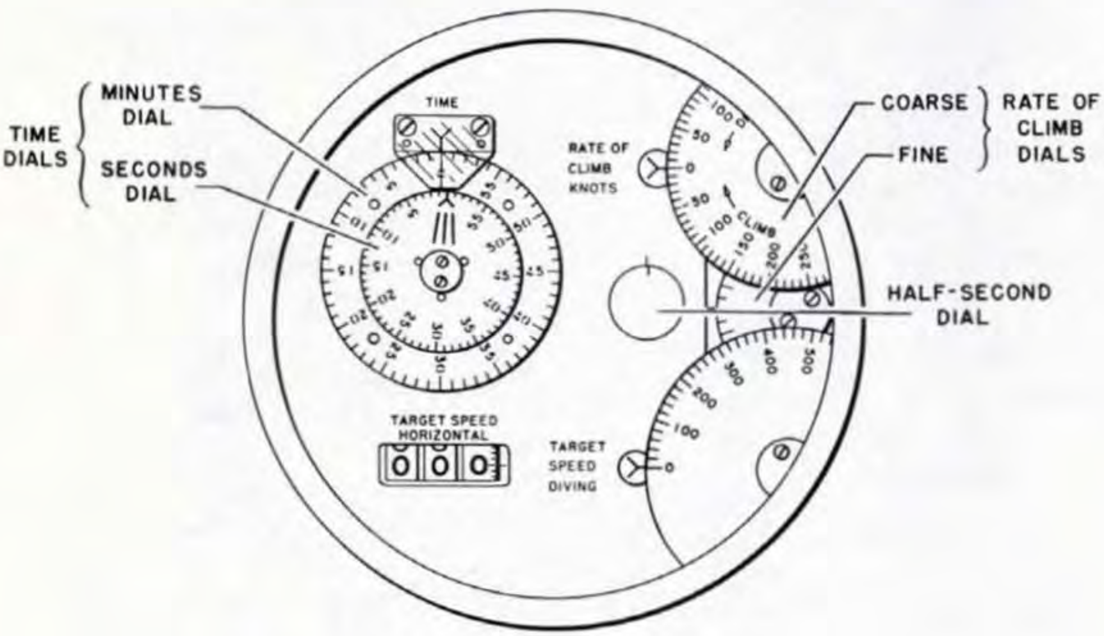


Figure 7. Target Speed Dial Group.

Table of Contents

tor switch, which has been removed from the computer. Operation of the new arrangement is given under the heading, "The Controls at the Range Station".

The power switch is unchanged.

Initial Velocity and Dead Time

Computer Mk 1A Mods 13, 14, 15, and 16 have two sets of initial velocity dials and knobs. One set is located on the lower left side, as in the Computer Mk 1. The other set is located on the lower front side. Both sets are identical. These dials show the value of initial velocity (*I.V.*) set into the computer. They are graduated in feet per second from:

2350 fs to 2600 fs for Mod 13
2250 fs to 2720 fs for Mods 14, 16
2400 fs to 2700 fs for Mod 15

Values of initial velocity are properly set into the computer only when both dials read alike. A legend plate stating this is located above the front *I.V.* dial.

The initial velocity dial and knob arrangement for Computer Mk 1A Mods 8 and 12 is the same as that of Computer Mk 1. The *I.V.* dial of Mods 8 and 12 is graduated in feet per second from 2400 fs to 2650 fs.

The dead time dial and knob are the same as those for Computer Mk 1.

The Controls on the Front of Computer Mk 1A

The controls on the front of Computer Mk 1A include the controls of the target and ship group, and those of the range station, the bearing station, and the elevation station. Differences between the controls and the description given in OP 1064 are set forth under the headings covering these separate groups below.

The Controls in the Target and Ship Group

The description in OP 1064 (pages 94 and 95) adequately covers this group for Computer Mk 1A.

The Controls at the Range Station

The description given under this heading in OP 1064 (page 96) is applicable to Computer Mk 1A except as noted below.

The Control Switch. In Computer Mk 1A, the three positions of the control switch are labeled NORMAL, TEST, and LOCAL instead of AUTO, SEMI-AUTO, and LOCAL.

With the control switch at NORMAL, bearing and elevation corrections are made automatically on signal from the trainer and pointer in the director.

With the control switch at TEST, no rate corrections can be made with the generated elevation and generated bearing cranks, as formerly. These cranks, whether IN or OUT, merely turn the generated elevation and generated bearing dials.

With the control selector at LOCAL, the rate control mechanism is inoperative. This type of operation is used against surface targets when the director is not operating.

The Range Rate Control Switch. The description for this switch given in OP 1064 is applicable to Computer Mk 1A if it is borne in mind that there is no Semi-Auto control of Computer Mk 1A.

The Range Time Constant Knob. This knob is called the range rate ratio knob on Computer Mk 1. The only identification appearing on it in Computer Mk 1A is the legend, SECONDS TIME CONSTANT, on the sleeve. The sleeve is graduated to indicate seconds (time constant), from 0 to 16, in 2-second intervals. The knob must be IN to make and hold a setting. Rotation of the knob in the IN position is limited from 1 (approximately) to 16 seconds. The value set at the knob indicates the time, in seconds, required for the range rate control mechanism to reduce a range rate error to approximately 37% of its initial value. For example, if range rate is in error by 150 knots and the knob is set at 2, in two seconds the range rate error will have decreased to approximately 55 knots. The OUT position is provided only to permit removal of the cover for adjustment or repair.

The Time Push Button. In Computer Mk 1A, the time push button is located beside the time dials and adjacent to the range rate control manual push button (see figure 5). The time motor can be stopped or started by momentarily depressing the button.

The Controls at the Bearing Station

The description of the controls at the bearing station given in OP 1064 (page 100) is applicable to Computer Mk 1A with the exceptions given below.

The Generated Bearing Crank. Since there is no Semi-Automatic control, it is immaterial whether this crank is in the IN or OUT position. (The gear for receiving hand inputs has been removed from the *jBr* line.)

The Controls at the Elevation Station

The controls at the elevation station consist of the generated elevation crank, the rate of climb handcrank, the air-surface switch, and the sensitivity push button. The location of the generated elevation crank is the same as for a Computer Mk 1. The other three controls are located as indicated in figure 5.

The Generated Elevation Crank. The function of the generated elevation crank is the same as described in OP 1064 for Computer Mk 1 with the exception that, there being no Semi-Auto control, no elevation rate corrections are introduced by the knob, and the knob can be left IN or OUT. (The gear for receiving hand inputs has been removed from the *jE* line.)

The Rate of Climb Handcrank. This hand crank has two operating positions, HAND and AUTO, selected by means of a lever. When the lever is at the HAND position, the handcrank is connected to the rate of climb gearing, allowing values of rate of climb to be put in manually. Shifting the lever to AUTO disconnects the handcrank from the rate of climb gearing and closes a switch that energizes the *dH* follow-up. In this condition, values of rate of climb are changed automatically by corrections coming from the rate control mechanism.

Air-Surface Switch. The air-surface switch, as the name implies, has two positions, AIR and SURFACE. It should be set at AIR for an air target, and at SURFACE for a surface target. When so positioned it adapts the operation of the sensitivity control system to the particular type of target, as described in the Detailed Description section of the addendum.

Sensitivity Push Button. The sensitivity push button provides a means of varying the action of the sensitivity mechanism of the Computer Mk 1A. The push button controls a switch that is normally closed. Depressing the push button opens the switch and causes the sensitivity mechanism to assume the position of maximum sensitivity. The mechanism is held in this position for a pre-set delay time after the push button is released, and then returns to the normal position. For a detailed description of the push button and sensitivity controls, refer to the Rate Control description in the Detailed Description section of this addendum.

Handcranks and Dials on the Rear Top of the Computer

The handcranks and dials on the rear top of Computer Mk 1A Mods 13, 14, 15, and 16 are the same as those for Computer Mk 1 (see page 102 of OP 1064). On Computer Mk 1A Mods 8 and 12, a dial has been added to the spot dial group as described below.

The Spot Group. The spot group of Computer Mk 1A is identical with that of Computer Mk 1 except for the elevation spot dial used in Computer Mk 1A Mods 8 and 12. In these modifications a transparent dial (figure 8) is secured directly over the *Vj* dial, on the same hub. The transparent dial is graduated in terms of range from 20,000 yards to 24,600 yards. The 20,000-yard graduation is aligned with the 0-graduation of the *Vj* dial. The spacing between each succeeding pair of graduations increases with range, as indicated in figure 8.

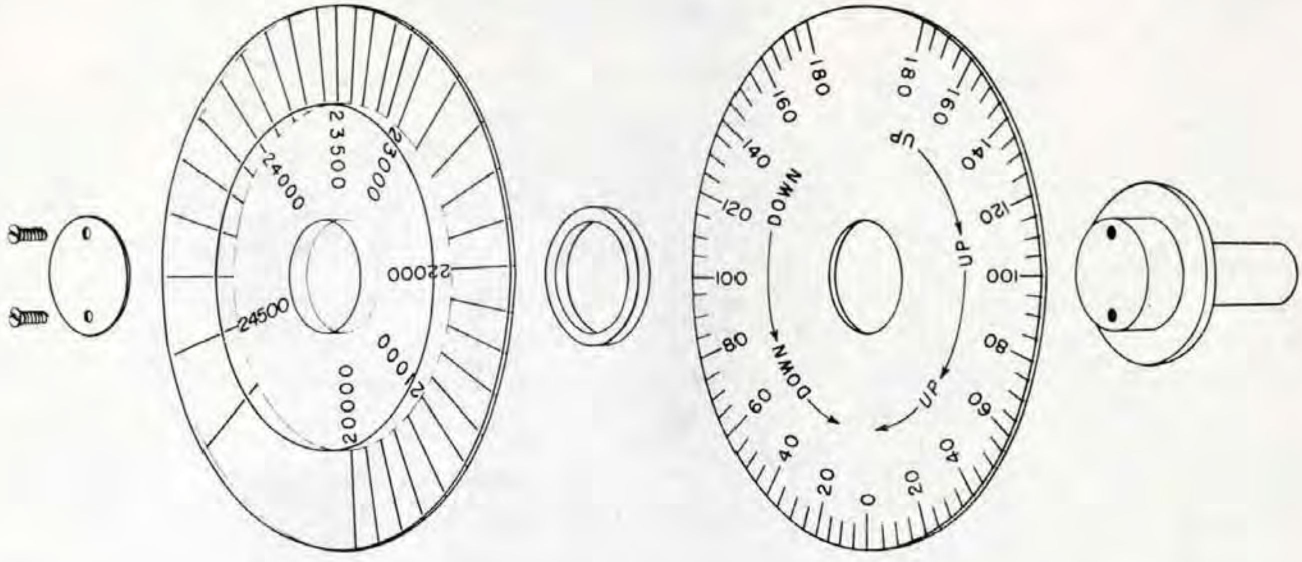


Figure 8. Elevation Spot Dials.

In the computer, the output of the superelevation cam is limited to values corresponding to a maximum range of 20,000 yards. However, at low position angles the extreme range of the guns exceeds this value of 20,000 yards.

When firing against surface targets at ranges beyond 20,000 yards, additional superelevation can be set into the instrument by means of the elevation spot knob. The correct amount to be set in is determined by means of the transparent range spot dial. The spacing of the graduations on this dial corresponds to the additional superelevation required for values of range beyond 20,000 yards. Therefore, when the transparent dial is set at a selected value of range, an amount of elevation spot (Vj) is introduced which will supply the additional superelevation required for that extended value of range.

The Target Course Indicator

The description of the target course indicator in OP 1064 (page 106) is applicable except that the target signal light is omitted from Computer Mk 1A.

The Star Shell Computer

The operating controls for the various modifications of Star Shell Computer Mk 1 are described on pages 107, and 356 to 367 in OP 1064. While Mod 3 is not specifically mentioned in OP 1064 because it was not designed at the time of writing, the controls for this mod are the same as for Mods 1 and 2.

It should be noted here that the knob designated STAR SHELL RANGE on the Mod 0 is replaced by a handcrank on the other mods. This handcrank is designated FUZE RANGE. Likewise, the knob designated STAR SHELL RANGE SPOT on the Mod 0 is designated as STAR SHELL RANGE on Mods 1, 2, and 3. Despite the two changes in designation, the functions of these knobs are unchanged.

Mods 1, 2, and 3 instruments have two additional handcranks: the deflection handcrank, and the elevation handcrank. As explained on pages 366 and 367, these handcranks are used to position elevation and deflection spot and search dials, which have also been added.

OPERATING INSTRUCTIONS

The automatic tracking controls incorporated in Computer Mk 1A as a result of Ordalt 2626 cause its operation to differ considerably from that of Computer Mk 1. The operator should, therefore, familiarize himself with these devices as described in the Detailed Description section of the addendum, and as shown schematically in figure 17. The operating instructions for Computer Computer Mk 1A differ from those for Computer Mk 1, as noted in the following description.

The Conditions of the Computer

The statements appearing under this heading in OP 1064 (page 111) are applicable to Computer Mk 1A except for those pertaining to basic types of operation. Computer Mk 1A has three basic types of operation: NORMAL, which is similar to AUTOMATIC for Computer Mk 1; and LOCAL and MANUAL which are the same as for Computer Mk 1.

Types of Operation

The description given in OP 1064 under the heading "The Types of Operation" (page 112) is applicable to Computer Mk 1A only to the extent defined in the following description. It should be noted that there is no Semi-Automatic operation of Computer Mk 1A.

In Normal operation the Rate Control Group computes corrected values of *Sh*, *dH*, and *A*. It does not function in Test or Local Operation.

Normal Operation. The description of Automatic Operation on page 112 of OP 1064 adequately describes Normal operation for Computer Mk 1A.

SWITCH POSITIONS:
Control Switch at NORMAL
Range Rate Control Switch at AUTO or MANUAL

Manual Operation. Manual operation is adequately described in OP 1064 (page 113).

SWITCH POSITIONS:
Control Switch at TEST
Range Rate Control Switch at MANUAL

Local Operation. This is the same as described in OP 1064 for Computer Mk 1.

SWITCH POSITIONS:
Control Switch at LOCAL
Range Rate Control Switch at MANUAL

Instructions for Operating Computer Mk 1A

Operation of Computer Mk 1A differs from that of Computer Mk 1 in such important respects as:

a. There is no Semi-Automatic control.

b. In setting up for Normal (Automatic) operation it is not necessary to apply inputs of estimated target angle, target speed, and rate of climb. Neither is it necessary for the computer operator to apply range inputs nor match the range dials during the search and tracking periods.

c. The computer time motor can be started from the director.

Because of the extensive differences between the operation of Computers Mk 1 and Mk 1A, the operating instructions given in OP 1064, pages 114 to 135 are NOT APPLICABLE to Computer Mk 1A except as specifically noted below.

Secured Condition

The nature of this condition is such that the instructions given in OP 1064 (page 114) are applicable for Computer Mk 1A with the following exceptions:

Securing the Computer Mk 1A.

AT THE RANGE STATION:

1. Stop the time motor by depressing the time motor push button.

Setting the Handcranks and Dials in Secured Condition.

AT THE RANGE STATION:

1. Turn the Control Switch to NORMAL.
3. Turn the Range Rate Control Switch to AUTO.
5. Set the Target Speed Handcrank Selector at AUTO.
6. Set the Range Time Constant Knob at 16.

AT THE ELEVATION STATION:

1. Set the Rate of Climb Handcrank Selector at AUTO.
6. Pull the initial velocity knobs OUT; set *I.V.* according to mod, as follows:

MOD	*I.V.*
8 & 12	2550 fs
13	2500 fs
14 & 16	2565 fs
15	2600 fs

8. Set Air-Surface switch at AIR.

AT THE BEARING STATION:

4. Set the Target Angle Handcrank at AUTO.

AT THE OTHER STATIONS:

4. With the Star Shell Fuze Range Handcrank IN, set the inner dial at 10,000 yards. Pull the handcrank OUT and set the outer dial at 10,000 yards. Push the handcrank IN.

Standby Condition

Initial standby, standby for search, and standby during search, are as described on page 116 of OP 1064 for Computer Mk 1.

Changing from Secured Condition to Standby for Search and Standby During Search. This procedure is as described on page 116 of OP 1064, except that the control switch of Computer Mk 1A is set at NORMAL.

Note: In Computer Mk 1A Mods 13, 14, 15, and 16 both initial velocity dials should be set at the ordered value of *I.V.*

Standby for an Air Target

When changing from standby during search to standby for an air target:

AT THE ELEVATION STATION:

1. With the Ship Speed Handcrank at IN set in the correct value of ship speed (*So*), then set the Ship Speed Handcrank at OUT. Note that *So* continues at the correct value.
2. With the Wind Speed Handcrank, set in wind speed (*Sw*).
3. Check that dead time (*Tg*) and initial velocity (*I.V.*) are at their ordered values.

AT THE BEARING STATION:

1. With the Wind Direction Handcrank, set in wind direction (*Bw*).

AT OTHER STATIONS:

1. Connect, synchronize, and lock the Selector Drive.
4. Pull Spot Knobs OUT, noting that correct values of *Rj*, *Vj*, and *Dj* are indicated.

Automatic Operation

Computer Mk 1A is ready for Automatic operation when properly set up for standby. Automatic operation commences as soon as the time motor is started. The normal procedure for starting the time motor is for the trainer to close his signal key; but the time motor also can be started by depressing the TIME push button on the computer.

Tracking in Automatic (Normal) Operation. The Computer will commence tracking when the trainer depresses his signal key, thus starting the computer time motor and closing the rate control clutches. During automatic (normal) operation:

AT THE RANGE STATION:

1. Keep the setting of the Range Time Constant Knob as low as possible without causing instability.
2. Computer Mk 1A matches *cR* with *R* automatically. If the range dials are out of synchronism and do not approach agreement with sufficient rapidity, they can be brought into synchronism more rapidly by momentarily shifting the range time constant knob to a high value. It should be noted that the range dials can also be matched by rotating the generated range crank in the OUT position.

AT THE ELEVATION STATION:

1. If range is below 8000 yards and the target maneuvers radically (the solution indicators spin), momentarily press the sensitivity push button.

Manual Operation Against an Air Target

This type of operation for Computer Mk 1A is the same as that described in OP 1064 (pages 126 to 131) for Computer Mk 1.

Standby for a Surface Target

Standby for a surface target is the same as standby for an air target (as described in the addendum) with the following exceptions:

AT THE RANGE STATION:

Note should be taken of the setting of the time constant control transmitter. This setting is normally made as a matter of adjustment procedure, the value of the setting being determined by doctrine.

AT THE ELEVATION STATION:

4. Set the Air-Surface switch at SURFACE.

Automatic (Normal) Operation (Surface Target)

Computer Mk 1A differs from Computer Mk 1 in that it can be operated against high speed (15 knots or higher) surface targets in Normal (Automatic) control. For low speed surface targets, manual rate control should be used. Tracking in automatic operation against a surface target is similar to that described for an air target. As long as the *dH* handcrank is kept at AUTO, the low elevation switch causes *dH* to be kept at zero in the instrument.

Local Operation

The procedure for Local operation is the same as described on page 136 of OP 1064.

Main Battery Operation

The use of Computer Mk 1A for main battery operation is the same as described in OP 1064 (page 144) for Computer Mk 1. Operation of the Mk 1A is, of course, limited to Automatic, Local, and Manual control.

Operating Cautions

The operating cautions given in OP 1064 (pages 156 to 159) for Computer Mk 1 are applicable to Computer Mk 1A, except for those pertaining to Semi-Auto operation. However, where limits are specified, the new limits of Computer Mk 1A should be substituted. Likewise, under the sub-heading "Setting *I.V.*", the design *I.V.* of the mod being considered should be substituted for the 2550 fs value given in the text.

It should be noted that Mods 13, 14, 15, and 16 instruments have two *I.V.* dials. The computer is not properly set up unless these dials are in agreement.

DETAILED DESCRIPTION

The Detailed Description section of OP 1064 is applicable to Computer Mk 1A when modified by the information contained hereunder.

RELATIVE MOTION AND INTEGRATOR GROUPS

The detailed descriptions of the relative motion group and the integrator group given in OP 1064 for Computer Mk 1 are applicable to Computer Mk 1A without any exceptions or alterations other than addition of the following material on the increase of target speed.

Increase of Target Speed

The speeds of potential targets have greatly increased. Therefore, alterations converting Computer Mk 1 to Computer Mk 1A include those which enable the relative motion group to handle higher input values of target speed. The maximum values at which normal operation can now be maintained are 800 knots horizontal target speed (*Sh*) and —500 knots vertical target speed (rate of climb, *dH*), in contrast to 400 knots and —250 knots, respectively.

Shaft Values

The basic alteration to increase range of operation of the relative motion group was the doubling of the values of the *Sh* and *dH* shafting (one revolution now equals twice as many knots as formerly). To keep the ship and wind mechanisms in agreement with the target mechanisms, the ship speed (*So*) and wind speed (*Sw*) shaft values also were doubled.

Speed Dials and Counter. Doubling of shaft values in the relative motion group was accomplished by changing the indicating ability of the speed dials and counter. The gear ratio at the target speed counter was changed so that the counter now indicates twice as large a number for a given position of the *Sh* shaft line. The ship speed dial was redesigned to indicate 45 knots at one-half revolution, the spacing of the graduations being halved in order to maintain its ability to indicate one knot intervals. It is graduated and numbered to 50 knots. In the case of wind speed and rate of climb, new dials, having the same graduations but doubled numbering, were supplied. It is to be noted that, while the ship speed dial is graduated only from 0 to 50 knots, one revolution of the dial is equivalent to 90 knots ship speed.

Integrator Group

Doubling the values of the speed input shafting results in doubling of the values of the relative motion rates (*dR*, *RdE*, and *RdBs*) shafting. Thus, the carriages of the range, elevation, and bearing integrators are moved one-half as much by a given change of relative motion group output as formerly. If this were not compensated for, indicated changes of range, elevation, and bearing would be only half the amounts called for by given relative motion rates over a particular time interval. In order to produce the proper output of range, elevation, and bearing, the integrator discs are driven at double their former speeds. That is, their former values per revolution were halved, each revolution now representing only half as much time. This was accomplished by changing a gear ratio in the time shaft line near the time motor.

RATE CONTROL

The necessity for more rapid rate control solutions and greater flexibility of operation is met by a new type of rate control system in Computer Mk 1A.

The target vector rate control system of Computer Mk 1A is, in general, similar to the rate control system of Computer Mk 1. The methods of rate control for Computer Mk 1A are the same as those for Computer Mk 1 except as noted hereunder.

There are three principal differences between the rate control group of Computer Mk 1A and that of Computer Mk 1, as follows:

1. Resolution of horizontal rate corrections is taken relative to the target vector, rather than to compass directions.
2. Inclusion of a sensitivity control mechanism in the elevation and bearing networks of Computer Mk 1A.
3. The use of additional automatic tracking controls in Computer Mk 1A.

Because of these differences, the target vector rate control system improves the performance of the computer by providing a faster rate solution. Converting to the target vector method of rate control makes it possible to operate the computer in automatic control against high speed (15 knots or over) surface targets by eliminating the low speed limitations imposed by the target vector solver. Introduction of the controls mentioned in item 3. simplifies the task of the computer operating crew during target acquisition.

Handcranks and Dials Used in Rate Control

The dials, handcranks, and switches used for rate control in Computer Mk 1A are shown in figure 5. These differ from those of Computer Mk 1 in the following respects:

a. Relocation of the *dH* handcrank.

b. Addition of the Air-Surface selector switch.

c. Addition of the sensitivity push button.

d. Addition of the time motor push button, and removal of the time motor switch.

How the Dials Receive Observed and Generated Values. In Computer Mk 1A the comparison of observed and generated values of range, elevation, and bearing is the same as described in OP 1064 (pages 216 and 217) for Computer Mk 1.

The Rate Control Computing Mechanism

The mechanisms of the rate control group of Computer Mk 1A (see figures 9 and 10) are the same as those in Computer Mk 1, with the following exceptions:

1. There is no vector solver.
2. Mechanism for controlling sensitivity of the elevation and bearing networks (figure 10) has been added. This comprises the following separate mechanisms: two 3-inch disc integrators, a single-speed rate control range receiver, a time constant control transmitter, and a time delay relay.
3. A follow-up for the *jHc* output has been added. This is designated as the *dH* follow-up.

The arrangement of the rate control computing mechanism for Computer Mk 1A is shown schematically in figure 24.

Because of the extensive differences between the Computer Mk 1 and Computer Mk 1A rate control systems, the arrangement of the following description of the Computer Mk 1A rate control system cannot closely parallel the arrangement of the description given in OP 1064. Reference to the comparative index on page 57 of this addendum will be a help in correlating the two descriptions.

The Rate Error Correction Measuring Network

In this network the differences between the generated and observed changes in range, bearing, and elevation are measured;

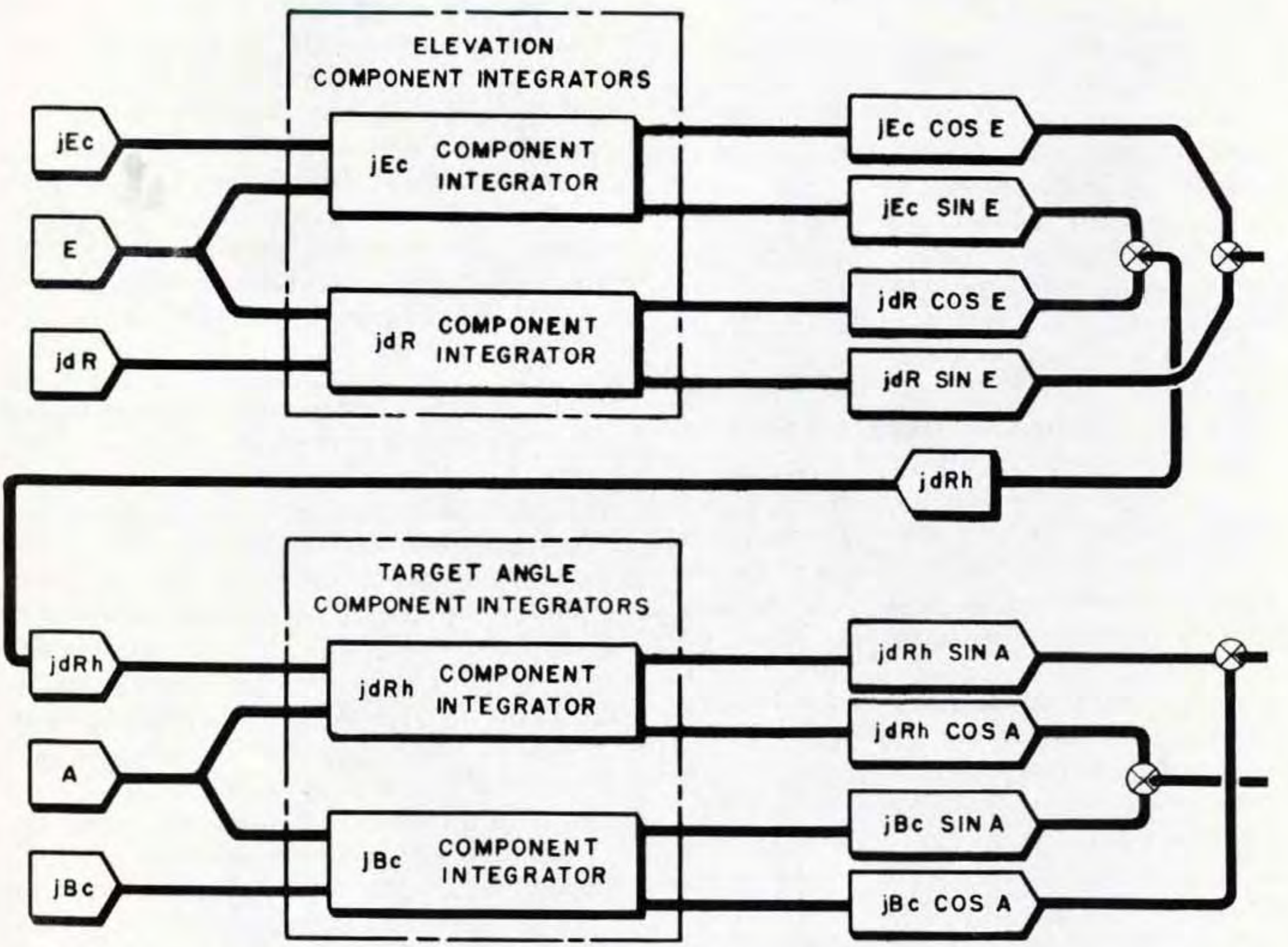
and the corrections to the target motion rates to be applied in the computer are determined. Measurement of the differences is accomplished in the same manner and by the same mechanisms in both Computer Mk 1 and Computer Mk 1A. This can be verified by reference to pages 242 to 247 in OP 1064 (particularly the diagrams on pages 243, 245, and 247) and by tracing the origin of *jdR*, *jE*, and *jBr* in the schematic diagram (figure 24). This diagram will be found at the back of this addendum. Determination of the rate control rate corrections (*jEc* in elevation, *jBc* in bearing) is different in Computers Mk 1 and Mk 1A. The measured elevation rate error (*jE*) and the measured bearing rate error (*jBr*), being angular quantities, are converted into linear quantities. In Computer Mk 1A this is accomplished by means of the elevation correction integrator and the bearing correction integrator, which are shown in figures 10 and 24. It can be seen that the integrator discs are driven by the angular measurements, while the carriages are positioned by range. Thus, the roller outputs of the integrators are products of the angular rate errors and range. The linear rate error corresponding to a given angular rate error is proportional to range, therefore the outputs of the integrators represent the linear rate error, *jEc* for elevation, *jBc* for bearing. These outputs are the rate error corrections set into the component integrators of the computer. For purposes of stability, it is desirable to make these corrections correspondingly less than the measured errors. This is accomplished by introducing less-than-unity gear ratios, *Ke* and *Kb*, in the *jE* and *jBr* shaft line inputs to the correction integrator discs. This affects the time constant of the instrument (the time required to reduce the error to 37% of its original value) as will be discussed in detail later. Change gears are provided so that the ratios may be conveniently altered if it is found desirable to do so.

Range rate errors are measured and corrected in Computer Mk 1A in exactly the same manner as in Computer Mk 1; see pages 246 and 247 in OP 1064.

Target Motion Correction Computing Network

Because of the method employed for computing relative motion rates in the Computer Mk 1A, the range rate correction (*jdR*), the elevation rate correction (*jEc*), and the bearing rate correction (*jBc*) cannot be added directly to the respective computed rates of *dR*, *RdE*, and *RdBs*. They must be resolved and applied as corrective changes to horizontal target speed (*Sh*), target angle (*A*), and rate of climb (*dH*). These corrective changes are obtained by resolving the rate corrections *jdR*, *jEc*, and *jBc* into horizontal and vertical components in the target motion correction computing network. This network consists of the elevation component integrators, the target angle component integrators, and related gearing and follow-ups. (See figure 9.) These basic mechanisms are the same as the corresponding ones in Computer Mk 1.

The elevation component integrators resolve range rate correction (*jdR*) and elevation rate correction (*jEc*) into horizontal and vertical components as described on pages 222 and 223 of OP 1064. The horizontal component (*jdRh*) is applied as an input to the target angle component integrators (see figure 10). The vertical component (*jHc*) is applied as a correction to *dH* at the *dH* follow-up. This follow-up is of the limited error type like the *jSh* and *jCt* follow-ups. Referring to figure 24, it is seen that in this type of follow-up, the follow-up differential spider shaft operates a limit stop, and that there is a friction drive in the input line. The arrangement is such that if either the *jHc* or the *dH* line is rotated while the follow-up is de-energized, a limit of the stop is soon reached, after which the friction drive permits continued rotation of either line. When energized, the follow-up needs to drive but a very short amount to synchronism, after which it will amplify any further input of *jHc*. This avoids having inputs that were made while the follow-up was de-energized upset by the follow-up running to synchronism when power is applied.


ELEVATION COMPONENT INTEGRATORS
jEc
E
jd R
jEc COMPONENT INTEGRATOR
jdR COMPONENT INTEGRATOR
jEc COS E
jEc SIN E
jdR COS E
jdR SIN E
jdRh
TARGET ANGLE COMPONENT INTEGRATORS
jdRh
A
jBc
jdRh COMPONENT INTEGRATOR
jBc COMPONENT INTEGRATOR
jdRh SIN A
jdRh COS A
jBc SIN A
jBc COS A

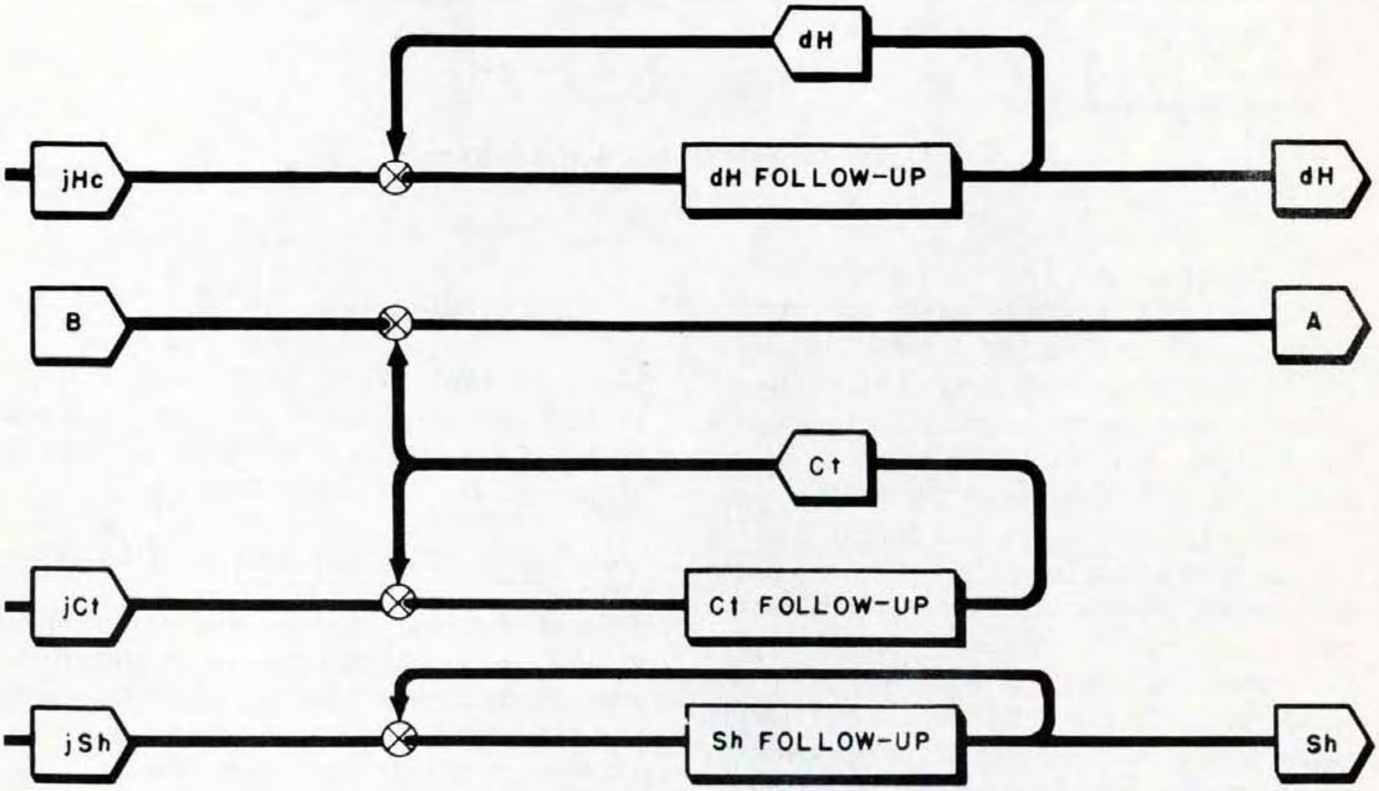


Figure 9. Target Motion Correction Computing Network.

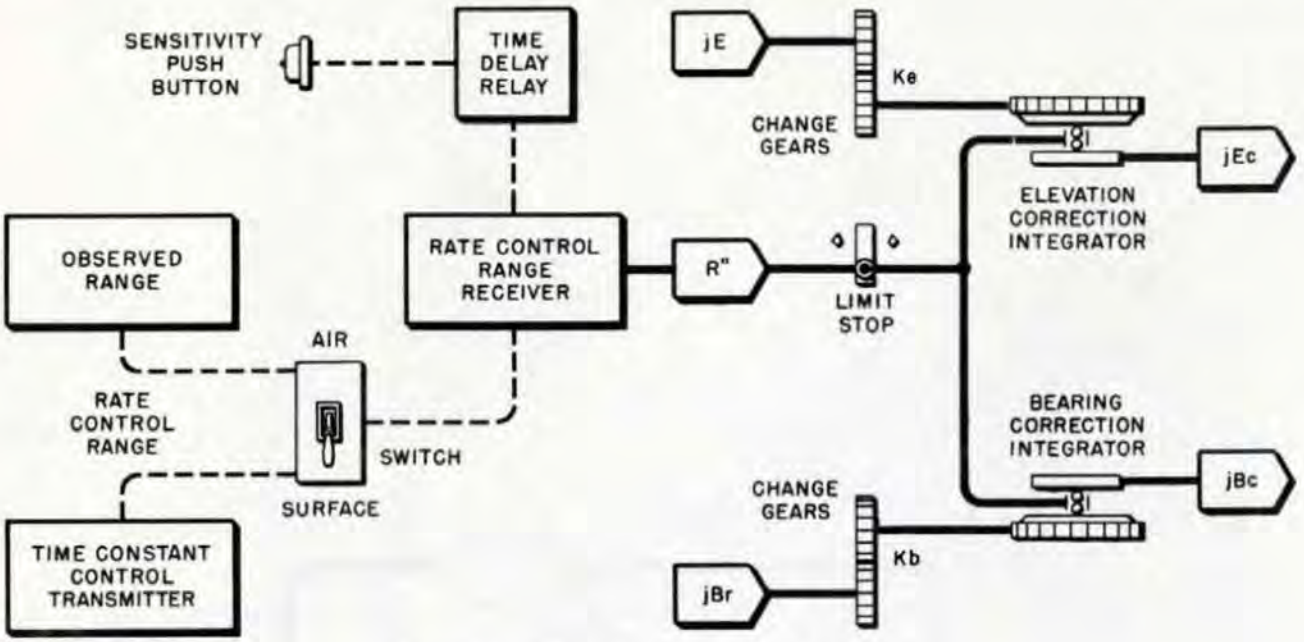


Figure 10. Sensitivity Control System.

In Computer Mk 1A bearing rate correction (jBc) and horizontal range rate correction ($jdRh$) are resolved into horizontal components taken with respect to the vertical plane through the target path (see figure 11), rather than with respect to a North-South line as in Computer Mk 1. Therefore, target angle (A) instead of target bearing (B) is used as an input to the target angle component integrators. The outputs from this component integrator group are jSh, the correction to target speed, and $jCt1$, the linear correction to the direction of target motion. Because these outputs are taken with respect to the line of target motion, the cumbersome vector solver used in Computer Mk 1 can be eliminated. One output, jSh, is applied to horizontal target speed (Sh) at the Sh follow-up. The other output, $jCt1$, is converted to the angular quantity $jCt1$ in the instrument gearing and applied to target angle (A).

Application of the linear correction $jCt1$ to the angular quantity A is as follows: It will be noted that changes in Ct are accompanied by corresponding changes in A. From figure 11 it is seen that the increment of change of target course (jCt) can be expressed by the equation:

$$jCt = \tan^{-1}\left[\frac{jCt1}{jSh}\right]$$

For such small angles as are involved, the tangent can be assumed equal to the corresponding arc expressed in radians. Thus the expression for jCt can be taken as:

$$jCt = \frac{jCt1}{2\pi Sh} \text{ x } 360 \text{ in degrees, or } jCt = \frac{jCt1}{K'Sh}$$

This expression indicates that for a given value of $jCt1$, jCt will vary with jSh. However, it has been determined that sufficiently accurate results can be obtained by assuming a constant speed, the expression thus becoming:

$$jCt = \frac{jCt1}{K}$$

This simplifies the mechanism, enabling the linear correction, $jCt1$, to be converted to an angular correction to Ct by means of gear ratios. This correction, jCt, is applied to Ct at the Ct follow-up. As indicated in figure 24 it is ultimately applied to target angle, A, in differential D-41 ($A = 180° + B - Ct$).

Sensitivity Control

Considered functionally, the sensitivity control of Computer Mk 1A is comprised of

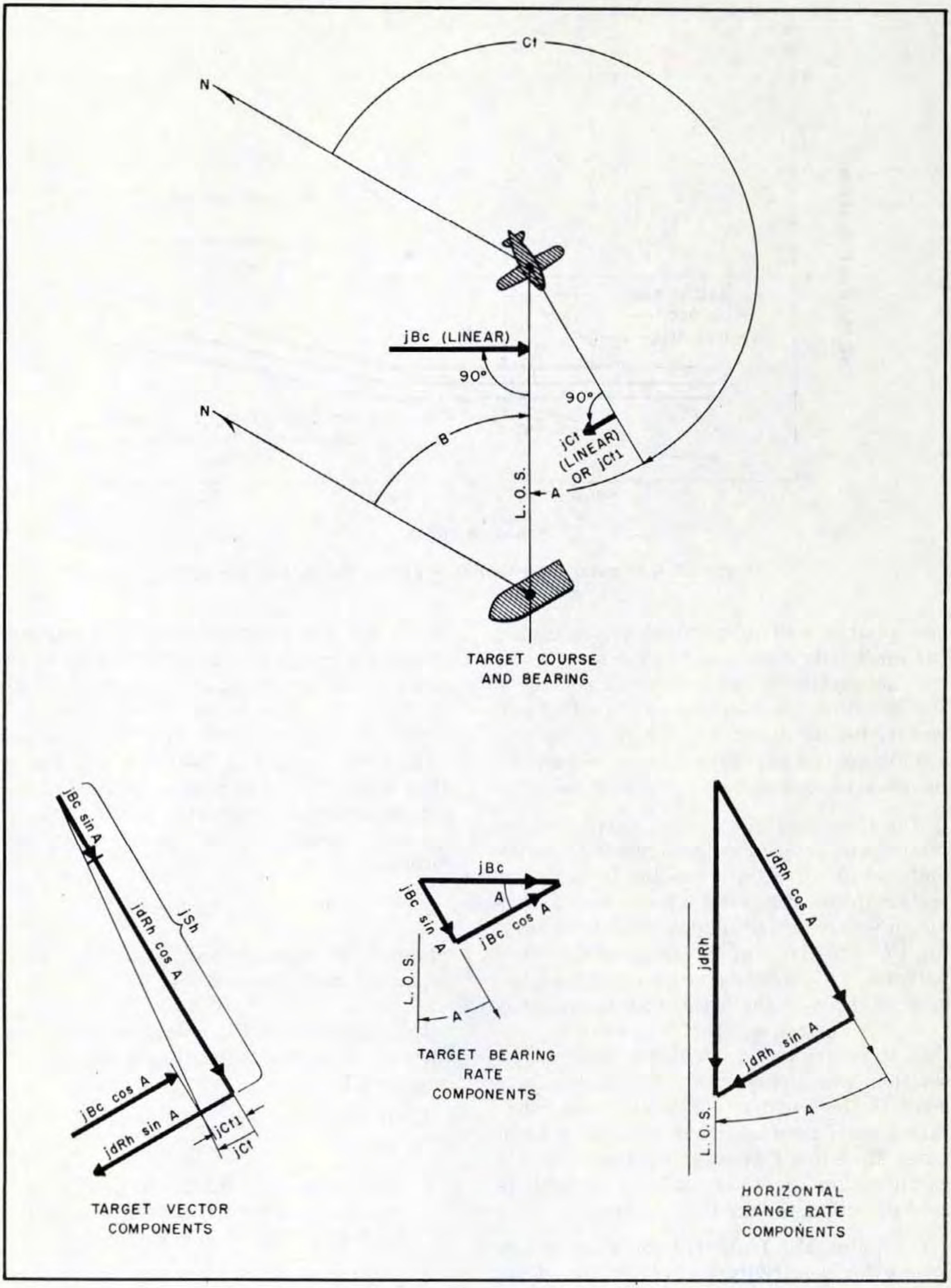


Figure 11. Vector Diagrams.

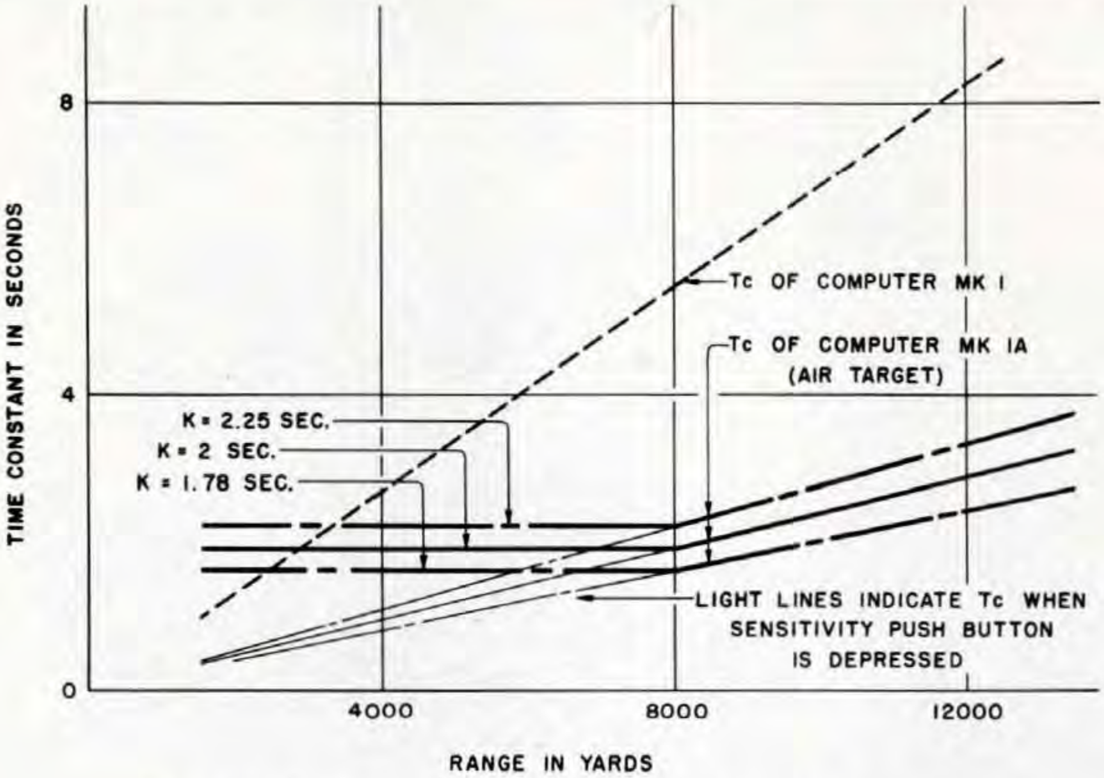


Figure 12. Computer Time Constant Versus Range (Air Target).

two separate and independent networks; i.e., the sensitivity control of the range rate control network, and the sensitivity control of the elevation and bearing rate control networks. Before describing either of the sensitivity control networks a more general description of sensitivity control must be given.

The time constant and sensitivity of the instrument determine the amount of target motion rate correction resulting from a given instantaneous rate error measurement. Provision was made in Computer Mk 1 for varying the sensitivity of the range rate control network. This made it possible for the operator to increase the sensitivity temporarily to hasten the reduction of large errors; and then to return to a more stable value as the solution was approached. No change was made in the sensitivity control of the range rate control network when altering a Computer Mk 1 to a Computer Mk 1A except for recalibrating the range rate ratio knob to read directly as range time constant.

Computer Mk 1 did not incorporate any means for sensitivity control of the elevation and bearing rate networks. The ratio of the difference between observed and generated changes in elevation or bearing to the resulting linear correction was fixed. Thus, the operator had no control over the sensitivity of these networks, and the time constant (Tc) varied at a fixed rate with range. (See figure 12.) The rate of change of the time constant of Computer Mk 1 with respect to range can be expressed by the formula:

$$Tc = \frac{R}{1430} \text{ (Approx.)}$$

where Tc is time constant in seconds, and R is present range in yards.

In Computer Mk 1A, operation of the elevation and bearing rate control networks is improved by:

1. Increasing the sensitivity of these networks.
2. Provision for maintaining the time constant uniform between the ranges of 500 yards and 8000 yards.
3. Provision of means whereby the operator can vary the sensitivity temporar-

ily (by temporarily changing the time constant).

These features are incorporated in the elevation and bearing sensitivity control network, a detailed description of which follows:

Sensitivity control mechanisms. The mechanisms involved in the sensitivity control network are the bearing, elevation, and range correction integrators; the time constant change gears; the rate control range receiver, the time constant control transmitter, the Air-Surface switch, the sensitivity push button, and the time delay relay. (See figures 10 and 24.)

CORRECTION INTEGRATORS. The integrators are of the disc type, the integrator for range having a four-inch disc and the integrators for elevation and bearing three-inch discs. The integrator for range is designated as the range correction ratio changer.

TIME CONSTANT CHANGE GEARS. Two sets of time constant change gears are provided for the elevation rate mechanism. Two identical sets are provided for the bearing rate mechanism also. The gears are engraved with time constant values and letters. The letters indicate the shafts on which they are installed. The gears engraved "A, $Tc = 2.00$" and "B, $Tc = 2.00$" form one set. When these gears are installed on shafts A and B, the basic time constant of the network in which they are installed is 2.00 seconds. The basic time constant is that value of Tc that is maintained uniform between the ranges of 500 yards and 8000 yards. It is also one of the factors determining the slope of the line representing the changing values of Tc beyond 8000 yards range. (See figure 12.) The basic time constant will be described further in the ensuing functional description; but it should be noted here that the basic time constant is inherent in the gearing of the system; the change gears merely providing a means of altering it.

The other change gears are engraved as follows:

Gear number 616728 (smaller gear)
A, Tc 2.25
B, Tc 1.78

Gear number 616729 (larger gear)
B, Tc 2.25
A, Tc 1.78

When the smaller gear is installed on shaft A and the larger gear on shaft B, the basic time constant is 2.25 seconds. When they are installed in the reverse manner, the basic time constant is 1.78 seconds.

It will be shown in the functional description that the time constant of the bearing rate control network varies with elevation as well as with range. Thus, in the bearing network, the value indicated by the installed gears is the basic time constant for this network only when the secant of target elevation (E) is 1.1, which occurs when E is approximately 25 degrees.

RATE CONTROL RANGE RECEIVER. The rate control range receiver is a single-speed receiver. Range is received by a 1F synchro motor. The synchro motor controls the position of the servo motor through a contact arrangement similar to that of the fine contact assembly of the range receiver located under the fine and coarse present-range dials.

TIME CONSTANT CONTROL TRANSMITTER. This is a 1G synchro transmitter. It transmits a predetermined value of rate control range. The transmitted range is indicated by a drum dial graduated from 0 to 10, representing zero to 10,000 yards. The transmitter can be set at predetermined values by turning a worm and gear type of adjustment on the transmitter shaft. Access to the adjustment is had by removing a pipe plug located below, and to the left of, the range time constant knob. It is called the time constant control transmitter because signals from it to the rate control range receiver affect the value of the time constant in surface fire.

AIR-SURFACE SWITCH. This is a double-pole, double-throw switch.

SENSITIVITY PUSH BUTTON. The sensitivity push button actuates a switch in which

the contacts are normally closed. Pushing the button opens the contacts.

TIME DELAY RELAY. The time delay relay is a double-pole, double-throw, solenoid-operated switch. The time delay characteristic is obtained by requiring the switch-actuating rod to compress and expel air from a chamber in the timing head before tripping the toggle switch. When the solenoid is energized, motion of the solenoid core compresses a spring. The spring, acting on a diaphragm, compresses the air in the timing head. The time delay is controlled by means of a regulating screw that governs the rate at which the air can be expelled through a needle valve. The switch operates at a predetermined point in the stroke of the diaphragm. When the coil is de-energized, the spring quickly returns the solenoid plunger and actuates the switch in the opposite direction.

Sensitivity Control of Range Rate Control Network

Sensitivity of the range rate control network is controlled through the range correction integrator. This unit functions in the same manner as it did in the Computer Mk 1 (see pages 236 to 239 in OP 1064). The only difference is in the knob used for positioning the carriage of the range correction integrator. As previously stated under "Operating Controls", this knob is now designated the range time constant knob, and the graduations used in setting it have been changed. In the Computer Mk 1A, it is graduated in terms of the time constant, from 0 to 16 seconds. The number at which the knob is set indicates the time (in seconds) required for a range rate error to be reduced to approximately 37% of its initial value.

Sensitivity Control of the Elevation and Bearing Rate Control Networks

Figure 10 shows schematically the network for controlling the sensitivity of the elevation and bearing rate control networks of Computer Mk 1A. In the figure, the dotted lines indicate electrical circuits. Inputs to the sensitivity control network are angular elevation rate error (jE), angular bearing rate error (jBr), and rate control range (R''). The latter quantity, R'', is the value of range represented by the actual position of the mechanism. It may, or may not, equal observed range, depending on circumstances of the fire control problem or on the conditions of operation. Changes in the input of R'' cause simultaneous changes in the sensitivity of the elevation and bearing rate control networks. The operation of the sensitivity control network in determining the amount of linear rate correction that is applied to reduce a given rate error is the same for both elevation and bearing. Therefore a description of the operation as applied to one network will serve for both.

Determination of elevation rate control sensitivity. It was indicated previously that the elevation correction integrator is used to multiply the angular elevation rate error (jE) by present range to obtain the equivalent linear elevation rate correcton. Accordingly, if rate control range (R'') equals present range (R) then either of the equations; $(R)\ (jE) = jEc$ or $(R'')\ (jE) = jEc$ expresses the value of the linear correction. But it also has been indicated that, for purposes of stability, the value of the linear rate correction actually applied in the instrument should be less than that expressed by the above formulas. This reduction is effected in two ways, as follows:

1. By introducing a fixed ratio having a value less than unity in the jE input.
2. By varying the value of R''.

The ratio in the jE input is incorporated in the gearing. It is thus fixed and not controllable by the operator. Designating this ratio as Q, the input to the elevation correction integrator disc becomes $[(Q)(jE)]$. Thus, with R'' equal to R the formula for jEc becomes:

$$jEc = R\ [(Q)(jE)]$$

However, if R'' is varied with respect to R, the output of the integrator varies in the same proportion. Thus, the complete expression for jEc is:

$$jEc = \frac{R''}{R}(R)\left[(Q)(jE)\right]$$

this can be rewritten to read:

$$jEc = \left[(Q)\frac{R''}{R}\right]\left[(R)(jE)\right]$$

The expression $(Q)\frac{R''}{R}$ indicates the actual sensitivity of the complete network. In discussing the operation of the network, it is more convenient to refer to the time constant (Tc), which is the reciprocal of the sensitivity factor; or $\left[\left(\frac{1}{Q}\right)\left(\frac{R}{R''}\right)\right]$. Letting $Ke = \frac{1}{Q}$, this becomes:

$$Tc = (Ke)\frac{R}{R''}$$

The subscript, e, indicates that the constant is applied to the elevation network.

The constant, Ke, is the basic time constant of the network. As long as the input of R'' equals R (i.e., the ratio $\frac{R}{R''} = 1$), Tc equals Ke, which, expressed in seconds, represents the time required for the network to reduce the error to 37% of the initial value. The constant Ke is introduced throughout the gearing of the instrument, the change gears previously referred to merely providing a selection of the values 1.78, 2.00, or 2.25 seconds.

The range input to the sensitivity control network is limited to a maximum value of 8000 yards. Referring to figure 10, it is seen that the input of R'' is derived from range sent to the rate control range receiver from either the rangefinder or the time constant control transmitter. When R'' is received from the rangefinder and is not more than 8000 yards, R'' equals R, and the time constant of the network is Ke. For ranges beyond 8000 yards but below 22,500 yards, the time constant increases uniformly because the ratio $\left(\frac{R}{R''}\right)$ no longer equals unity, R'' being held at 8000 yards while R continues to increase. As an example, with R at 16,000 yards, and 2-second change gears installed:

$$Tc = Ke\left(\frac{R}{R''}\right) = 2\left(\frac{16{,}000}{8000}\right) = 4 \text{ seconds.}$$

The values of Tc for all values of range is shown graphically in figure 12. The increasing values of Tc beyond 8000 yards provide greater stability but larger errors at long ranges. However, the increased stability improves the pattern of the projectiles at these ranges. Means are provided for changing the upper limit of the range stop from 8000 yards to 3000, 4000, 5000, 6000, or 7000. The effect of decreasing the upper limit of R'' is indicated in figure 13. It can be seen that, below the limit, Tc remains constant; while for values of range beyond the limit, the time constant increases as the value of the limit decreases.

Determination of bearing rate control sensitivity. As previously stated, bearing rate control sensitivity is similar to that for elevation. It differs in but one respect; the time constant of the bearing network varies with the value of elevation (E), as well as with range, because the horizontal projection of range ($R \cos E$) determines the linear bearing rate correction required. Accordingly, the relationship between linear and angular bearing rates is:

$$jBc = (R \cos E)(jBr)$$

Inserting the sensitivity factor:

$$jBc = Q\left[\frac{R'' \cos E''}{R \cos E}\right](R \cos E)(jBr)$$

in which E'' is the value of elevation actually entering the sensitivity control mechanism. A constant value of E'' is selected as satisfactory for the purpose of computing rate corrections, as explained below. Since the cosine of a constant angle is itself a constant, $\cos E''$ can be replaced in the equation by $K1$. Thus, the expression for jBc becomes:

$$jBc = (Q)\left[\frac{(R'')\ (K1)}{R \cos E}\right](R \cos E)(jBr)$$

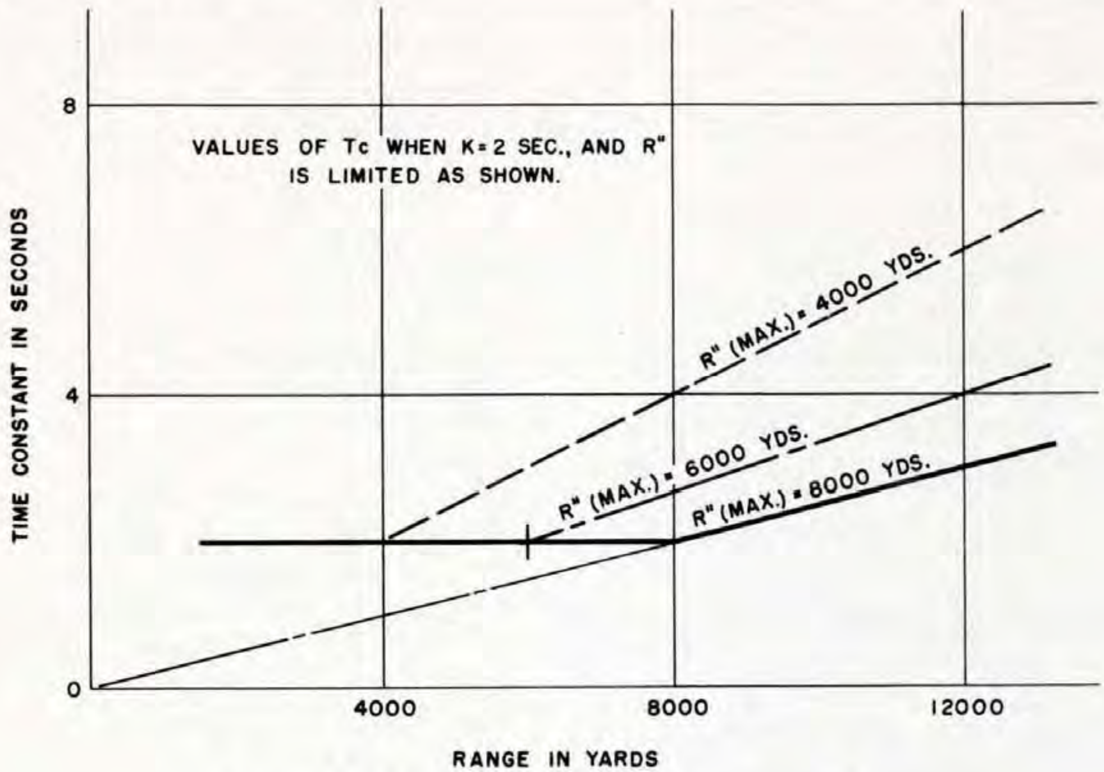


Figure 13. Effect of Decreasing Upper Limit of R″.

Letting $Kb = \frac{1}{Q}$ the expression for the time constant of the bearing rate control network becomes:

$$Tc = Kb\left[\frac{R\ (\cos E)}{(R''K1)}\right]$$

The subscript b of Kb merely indicates that the constant applies to the bearing network.

The formula for Tc in bearing can be rewritten as follows:

$$Tc = Kb\left[\left(\frac{R}{R''}\right)\cos E\right]\frac{1}{K1},\ \text{or}$$

$$Tc = Kb\left[\left(\frac{R}{R''}\right)\cos \mathrm{E}\right]\sec E'',$$

sec E'' being $\frac{1}{\cos E''}$ or $\frac{1}{K1}$.

From the above, the desirability of selecting a value for $K1$ that approximates the secant of E over a wide range of variation can readily be seen. The constant 1.1 is applied in the instrument gearing as $K1$. The secant of 0° being 1.0, and the secants of 25° and 35° being approximately 1.1 and 1.2, respectively, the selection of 1.1 as the value of $K1$ represents a reasonable mean value for usual fire control problems. Thus, as long as target elevation does not exceed 35° the values of Tc given in figure 12 can be applied to the bearing network without serious error.

Summary of Operation of the Elevation and Bearing Sensitivity Control Network

It has been shown that the only difference between the elevation and bearing time constant in Computer Mk 1A is the factor $\frac{K1}{\cos E}$. For simplicity, this distinction will be ignored in the following description, the elevation and bearing time constants being considered equal.

The bearing and elevation time constant of Computer Mk 1 can be expressed by the formula $Tc = \frac{R}{1430}$, in which R equals range in yards. (See figure 12.) No provision was made for operational control of this time constant.

As indicated in figure 12, the time constant of Computer Mk 1A was made shorter

than that for Computer Mk 1 at long ranges. However, these values of Tc are still large enough to provide sufficient stability to insure small dispersion patterns. The constant value of Tc shown for short ranges is a compromise between stability and fast solution time. In Computer Mk 1A, provision is made for altering the value of Tc at the will of the operator. Thus faster solution times can be obtained than those provided by the uniform value of Tc, as indicated by the light lines in the figure. The operator controls the operation of the sensitivity control network by means of the Air-Surface switch and the sensitivity push button.

Air targets. For operation against air targets the Air-Surface switch is positioned at AIR. The range input from the rangefinding equipment then actuates the rate control range receiver, and the value of R'' applied in the network is equal to R, up to the limit of 8000 yards. With the 2-second Tc gears installed, the formula for the time constant $\left(Tc = K\frac{R}{R''}\right)$ becomes:

1. For ranges to 8000 yards, $Tc = 2$.
2. For ranges beyond 8000 yards,

$Tc = 2 \times \frac{R}{8000} = \frac{R}{4000}$. Figure 12 shows this graphically.

If conditions of the problem indicate the desirability of increased sensitivity, it can be obtained when range is 8000 yards or less by depressing the sensitivity push button.

The rate control range receiver (figure 10) is of the type wherein both coils of the servo motor stator are energized directly by the power supply when the input and output are in synchronism. Depressing the sensitivity push button opens the time delay relay solenoid circuit. The relay then operates as previously described under the heading "sensitivity control mechanism", and shifts the single letter side of the power supply from the center contact of the receiver follow-up to the left lead of the rate control servo motor, at the same time disconnecting the left follow-up contact from the left side of the servo. With the left side of the servo connected directly to the power supply, the motor then drives range to the upper limit. After the sensitivity push button is released, the time delay relay maintains the direct connection to the left lead of the servo for the duration of the delay period, which is usually set at approximately two seconds.

From the above, it is seen that depressing the sensitivity push button causes the input, R'', to remain at 8000 yards for a brief period. During this time the ratio, $\frac{R}{R''}$, in the formula, $Tc = (2)\ \frac{R}{R''}$ will not equal unity, and the time constant for any range under 8000 yards will be shortened as indicated by the light lines in figure 12.

Figure 14 shows the effect of depressing the sensitivity push button on a typical problem in which range is changing.

Surface fire. It has already been indicated that Computer Mk 1A can be operated automatically against surface targets (normal control in Computer Mk 1A being the same as automatic control in Computer Mk 1). For such operation, the Air-Surface switch is set at SURFACE. When so positioned, it disconnects the rate control range receiver from the rangefinder, and connects it instead to the time constant control transmitter. The input to the rate control range receiver from the time constant control transmitter is equivalent to a fixed value of range. Assuming the control transmitter to be set to transmit a value equivalent to 3000 yards, the formula expressing the time constant of Computer Mk 1A (2-second time constant gears being installed) for surface fire is:

$Tc = (2)\ \frac{R}{3000}$ or $Tc = \frac{R}{1500}$. This gives values of Tc with respect to range approximately equal to those shown in figure 12 for Computer Mk 1. The effect of other settings on the time constant is indicated in figure 15. Increased sensitivity can be obtained by depressing the sensitivity push button. This has the effect of setting R'' at a fixed value equal to the upper limit of the stop. The R''

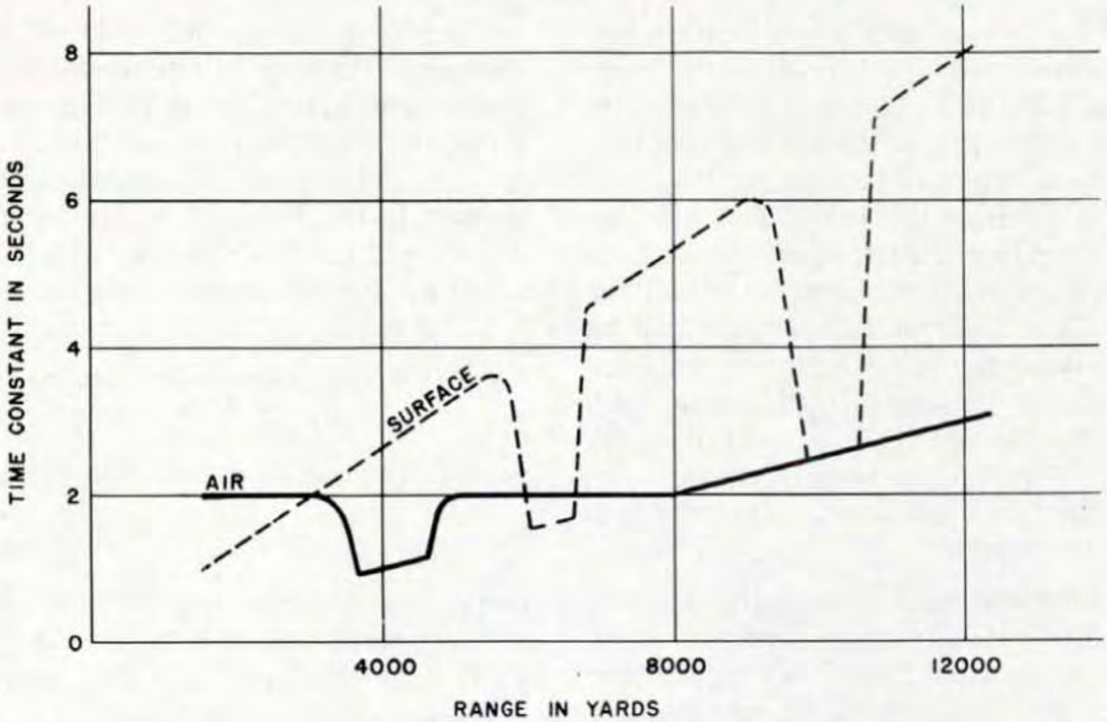


Figure 14. Effect of Depressing Sensitivity Push Button on Computer Time Constant.

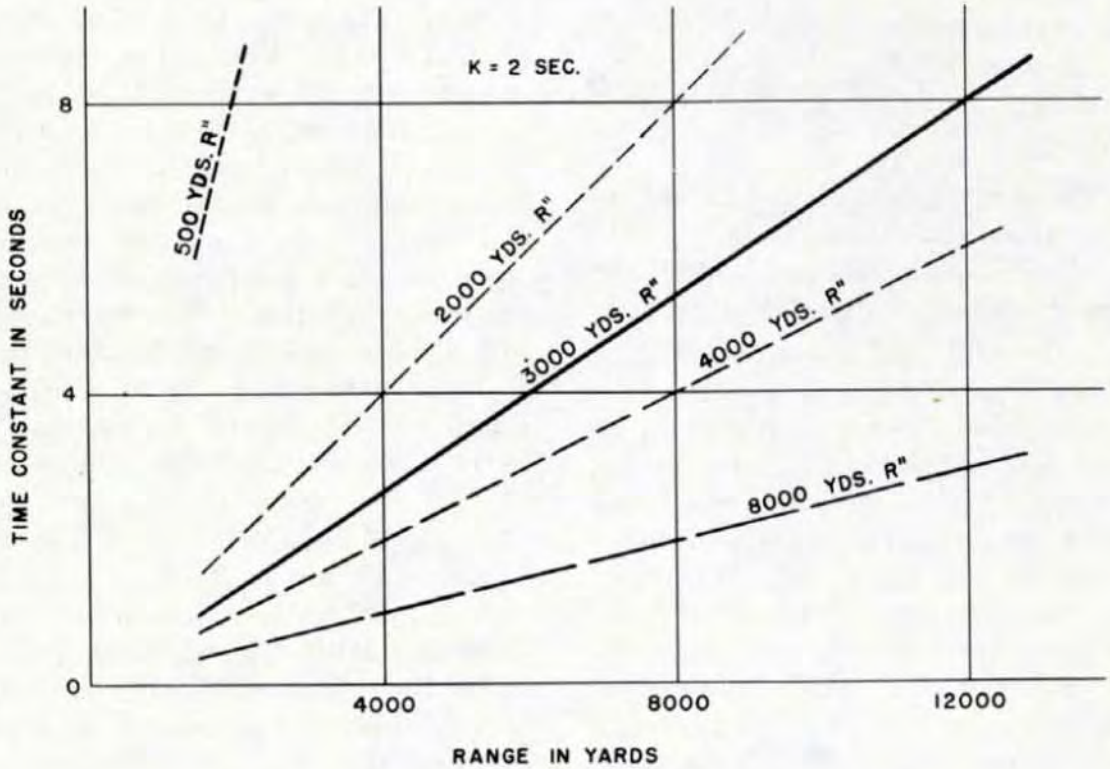


Figure 15. Effect of Time Constant Control Transmitter Setting on Tc.

Table of Contents

input is held at this higher value for approximately two seconds after the sensitivity push button is released. The resultant effect on a typical problem is indicated in figure 14. Two conditions are shown; one for a range greater than 8000 yards, one for a shorter range.

Local Control

In local control the rate control computing mechanism is inoperative. In this form of operation Computer Mk 1A performs in the same manner as described in OP 1064 for Computer Mk 1 (pages 208 to 213).

Normal (Automatic) Control

Normal control of Computer Mk 1A corresponds to automatic control of Computer Mk 1. Therefore, the description of automatic operation contained on pages 241 to 247 of OP 1064 is adequate for Computer Mk 1A when modified by the information given in this addendum. However, it should be noted that illustrations on these pages of OP 1064 showing the rate control computing mechanisms do not show the parts entirely as they are in Computer Mk 1A. To rectify this condition, reference should be made to figures 9, 10, 16, 17, and 24 in this addendum.

Differences in the Mk 1 and Mk 1A rate control mechanisms have already been described in this addendum. Figure 16 shows the Mk 1A rate control mechanism in Normal Control. The control circuits governing the operation of the rate control mechanism of Computer Mk 1A differ from those of Computer Mk 1. The Mk 1A circuits are described below, and are shown schematically in figure 17.

Automatic Tracking Controls

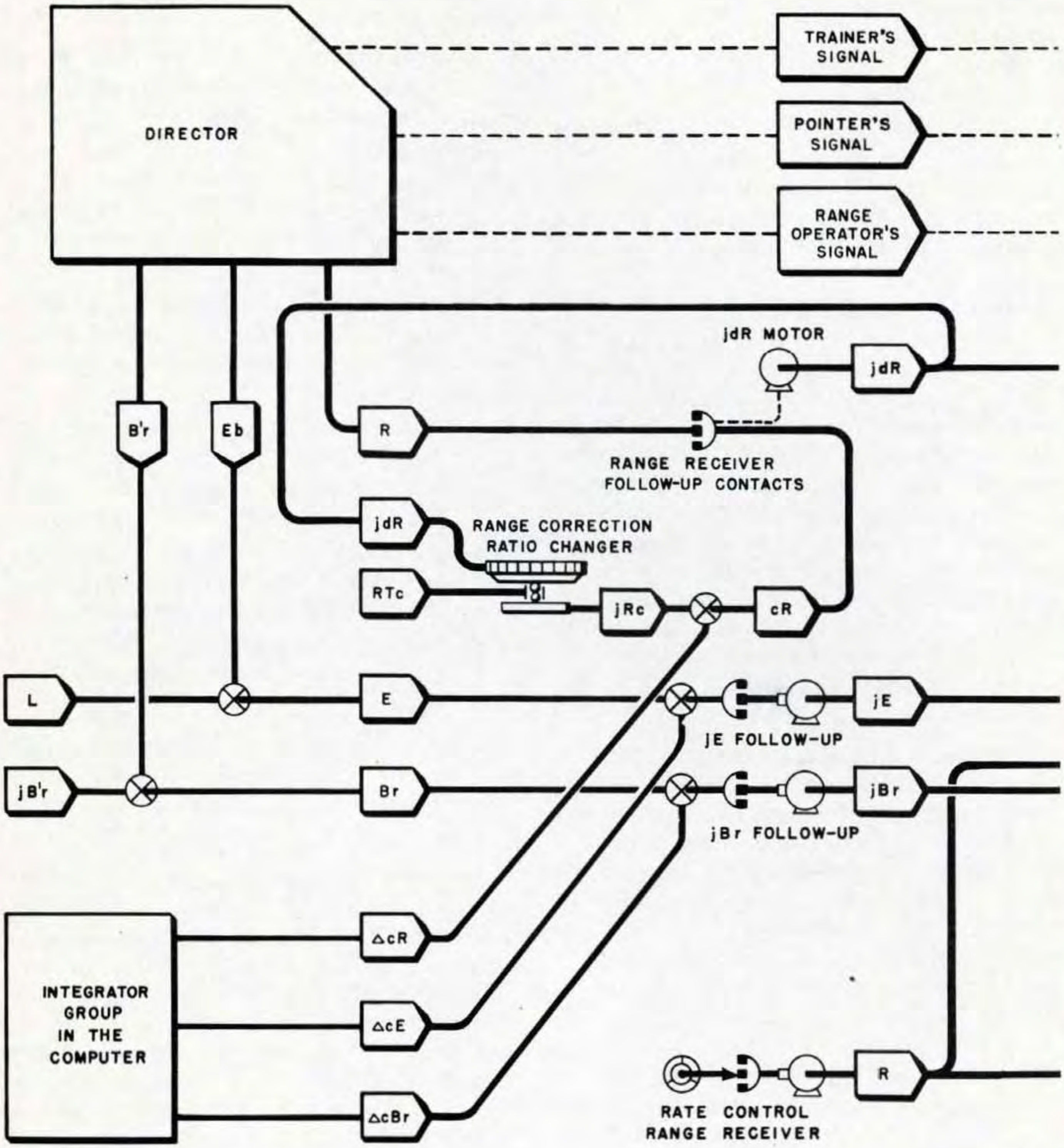
For full automatic operation of Computer Mk 1A the Control Switch is set at NORMAL and the Range Rate Control Switch is set at either AUTO or MANUAL. The basic features of operation in this condition are fully described above. However, normal operation is affected by operation of the automatic tracking controls which are described in detail below. Reference should be made to figures 16 and 17 throughout the following description.

The automatic tracking controls added to Computer Mk 1A operate to:

1. Automatically start the time motor when the director first indicates that it is "on target".
2. Automatically keep the generated range and the observed range dials in agreement even though the rangefinding equipment does not indicate that it is "on target".
3. Prevent the *jdR* clutch from being closed unless generated range is within 700 yards of agreement with observed range.
4. Automatically slew target angle until rate control increases target speed (*Sh*) above four knots, and target angle (*A*) is less than 90° in error.
5. Automatically set target speed (*Sh*) and rate of climb (*dH*) at zero when the time motor is not running.
6. Transmit an electrical signal to the director when target elevation (*E*) is less than two degrees.

The purpose of these controls is to simplify and improve the operation of the gun fire control system in the following respects:

In Computer Mk 1, initial estimates of target motion (*A*, *Sh*, and *dH*) must be set in the computer to establish initial target motion rates. But when the time motor is started, these rates are transmitted to the director where they are superimposed on whatever signal is positioning the director, and thus tend to drive the director off the target. In addition, if an incorrect estimate of *A* has been applied (or if no estimate of *A* is available), so that the applied value of *A* differs greatly from the actual value, considerable time is required for the computer to arrive at a correct rate control solution. A further disadvantage of this system is that during the interval between the time the


DIRECTOR
TRAINER'S SIGNAL
POINTER'S SIGNAL
RANGE OPERATOR'S SIGNAL
jdR MOTOR
jdR
B'r
Eb
R
RANGE RECEIVER FOLLOW-UP CONTACTS
jdR
RANGE CORRECTION RATIO CHANGER
RTc
jRc
cR
L
E
jE
jE FOLLOW-UP
jB'r
Br
jBr
jBr FOLLOW-UP
INTEGRATOR GROUP IN THE COMPUTER
ΔcR
ΔcE
ΔcBr
R
RATE CONTROL RANGE RECEIVER

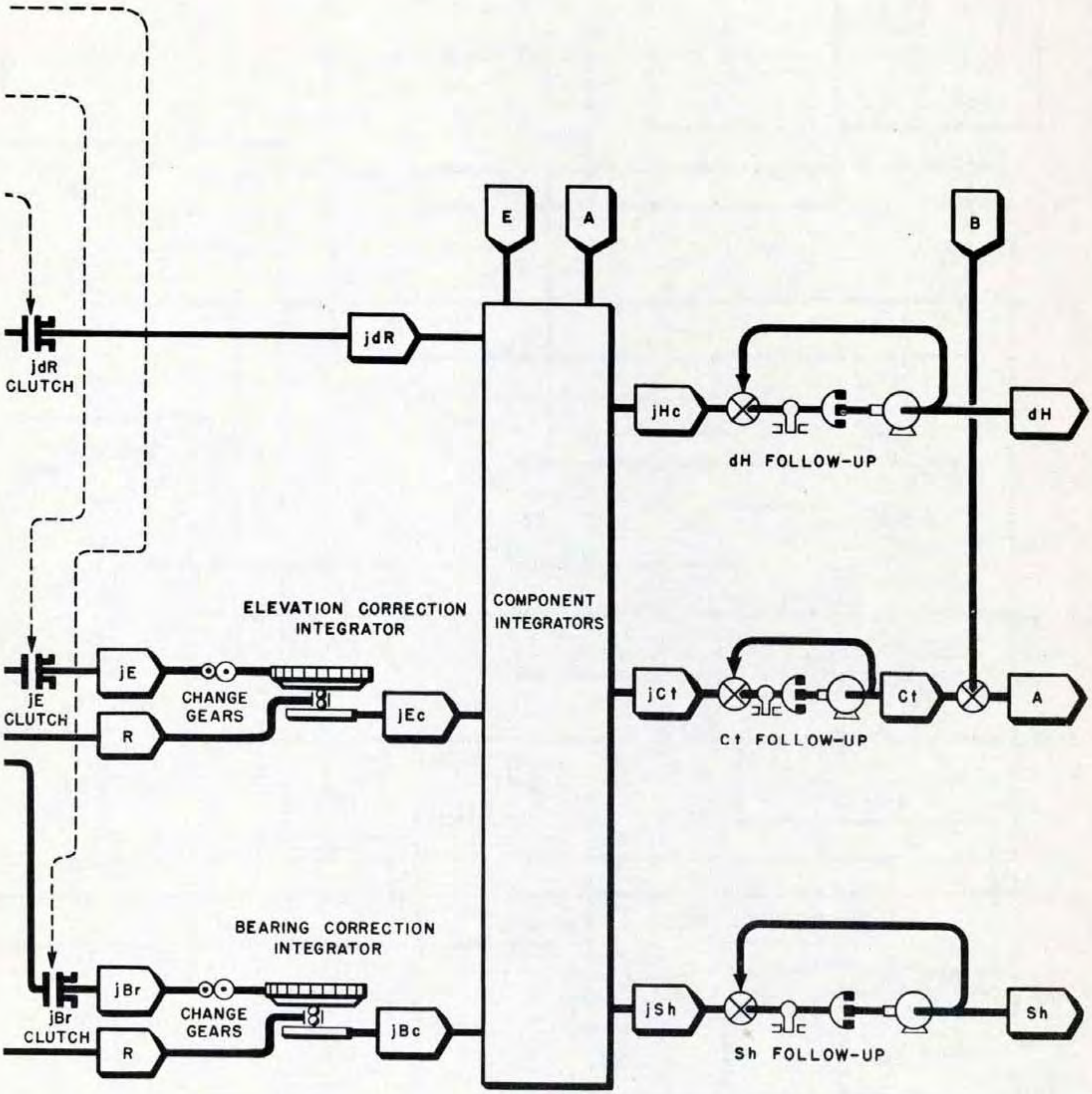
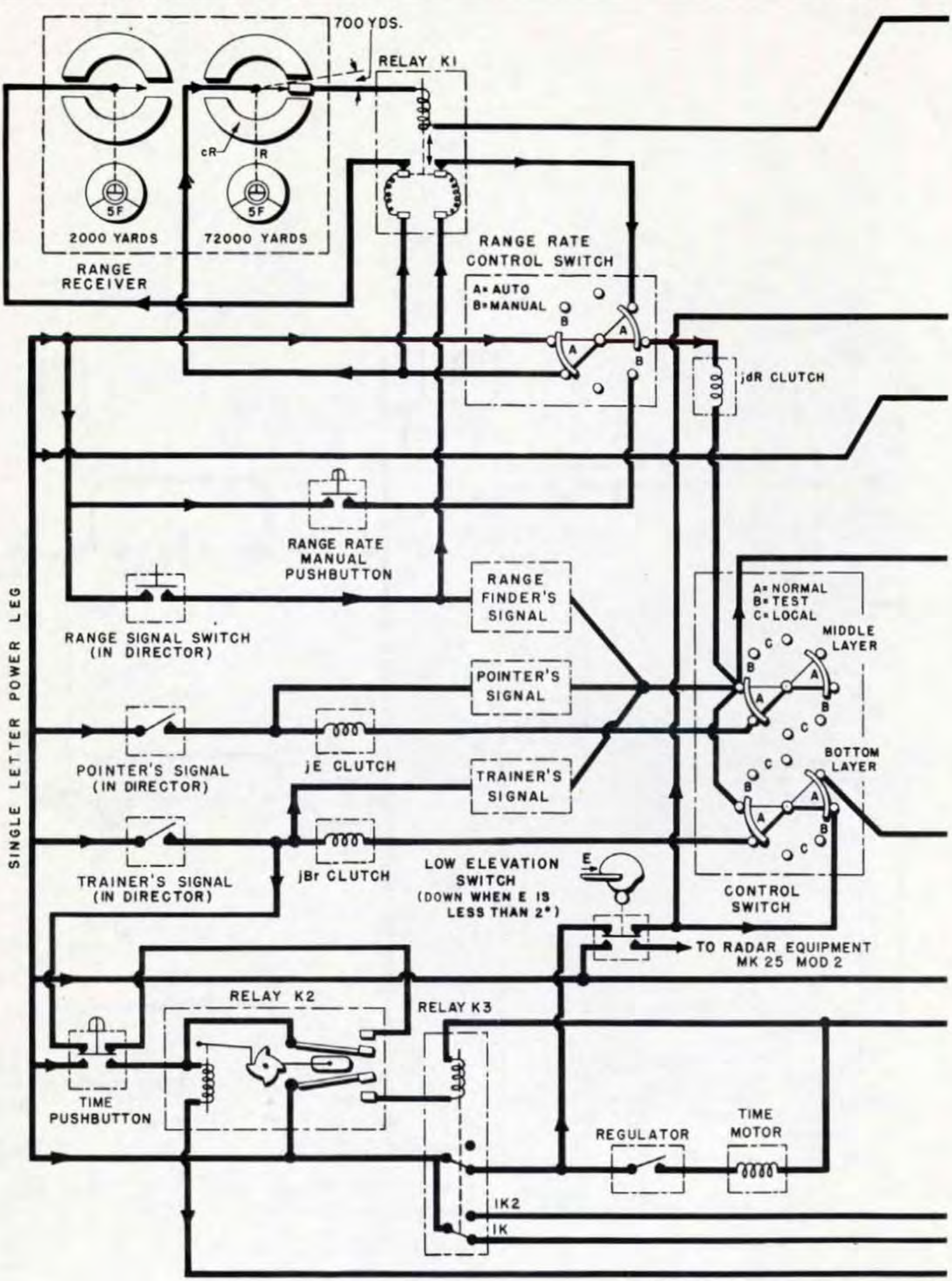


Figure 16. Flow Schematic (Normal Control).



700 YDS.
RELAY K1
cR
IR
5F
5F
2000 YARDS
72000 YARDS
RANGE RECEIVER
RANGE RATE CONTROL SWITCH
A= AUTO
B= MANUAL
jdR CLUTCH
RANGE RATE MANUAL PUSHBUTTON
RANGE FINDER'S SIGNAL
RANGE SIGNAL SWITCH (IN DIRECTOR)
SINGLE LETTER POWER LEG
POINTER'S SIGNAL
POINTER'S SIGNAL (IN DIRECTOR)
jE CLUTCH
TRAINER'S SIGNAL
TRAINER'S SIGNAL (IN DIRECTOR)
jBr CLUTCH
A= NORMAL
B= TEST
C= LOCAL
MIDDLE LAYER
BOTTOM LAYER
CONTROL SWITCH
LOW ELEVATION SWITCH (DOWN WHEN E IS LESS THAN 2°)
E
TO RADAR EQUIPMENT MK 25 MOD 2
RELAY K2
RELAY K3
TIME PUSHBUTTON
REGULATOR
TIME MOTOR
IK2
IK

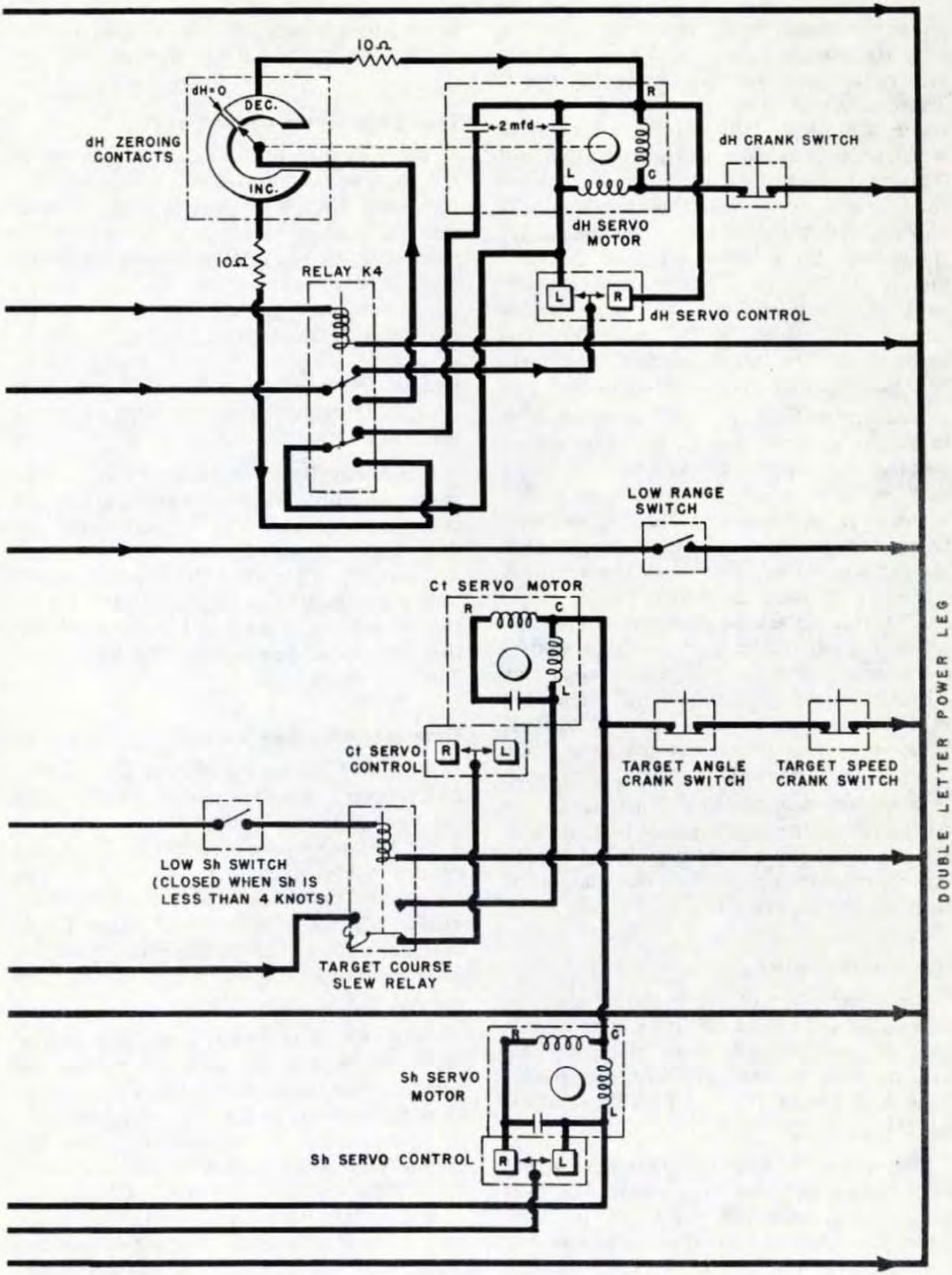


Figure 17. Automatic Operating Controls.

trainer indicates he is "on target" and the time the computer operator starts the time motor, the computer rate system is upset. These disadvantages are reduced in Computer Mk 1A by the control mechanisms which operate as indicated in items 1, 4, and 5 above. In Computer Mk 1A, the computer rates are at zero when the time motor is started, and the director is not driven off the target. With the starting of the time motor, *A* will be slewed to the proper quadrant if necessary, and the correct rates quickly established in the computer. The necessity for the introduction of target motion rates by the operator is eliminated.

Another purpose of the added controls is to relieve the operator of the necessity of keeping the generated and observed range dials matched during the period of target acquisition. In Computer Mk 1A, the electrical circuits have been so arranged that the *jdR* motor keeps these dials synchronized whenever the range rate control switch is at AUTO. If observed range changes too rapidly for the *jdR* motor to follow, the control mechanism opens the *jdR* clutch when the difference between observed and generated range becomes 700 yards (item 3 above). This prevents erroneous range rates from being set into the computer.

There are several other functions of the automatic control mechanisms of Computer Mk 1A. These will be explained in the following description which gives the details of each control separately.

The Control Switch

The description of the control switch on pages 258 and 259 of OP 1064 is applicable to Computer Mk 1A when the following substitutions in the wording are made: NORMAL for AUTO, and TEST for SEMI-AUTO.

The pointer's and the trainer's signal keys. These switches function as described in OP 1064, pages 258 and 259. In Computer Mk 1A, the trainer's signal key has the additional function of starting the time motor upon a shift to Normal control. This is explained in detail in this addendum under the heading "Time Motor Control System".

The Range Rate Control Switch

The description of this switch given in OP 1064, pages 260 and 261, is adequate for Computer Mk 1A when it is borne in mind that there is no Semi-Auto rate control in Computer Mk 1A. Another important difference is that in Computer Mk 1A, turning the range rate control switch to AUTO energizes the range receiver. This operation is entirely independent of the completion of circuits in the director. Thus, in automatic control, the range dials are kept in agreement at all times.

The Range Operator's Signal Button. The range operator's signal button in the director controls the operation of the *jdR* clutch and rangefinder signal, as described on pages 260 and 261 of OP 1064. However, relay K1 of the automatic tracking controls modifies this operation, as described under the heading "Control of Range Input" in this addendum.

Time Motor Control System

Figure 18 shows the system for starting and stopping the time motor. As shown in the figure, the system is in the "Power On—Time Motor Stopped" condition. Thus, the ratchet operated contacts of relay K2 are closed, and the solenoid of relay K3 is energized. When the solenoid of relay K3 is energized, the switch of this relay opens the time motor line, thereby stopping the time motor.

Relay K2 is so constructed that successively energizing its solenoid causes the ratchet mechanism alternately to open and close the contacts in the relay; i.e., one cycle of operation of the solenoid will cause the contacts to open, the next will cause them to close. With the computer power ON, depressing the time motor push button energizes this solenoid. Likewise, closing the trainer's signal key will energize the solenoid when the system is in the condition shown in

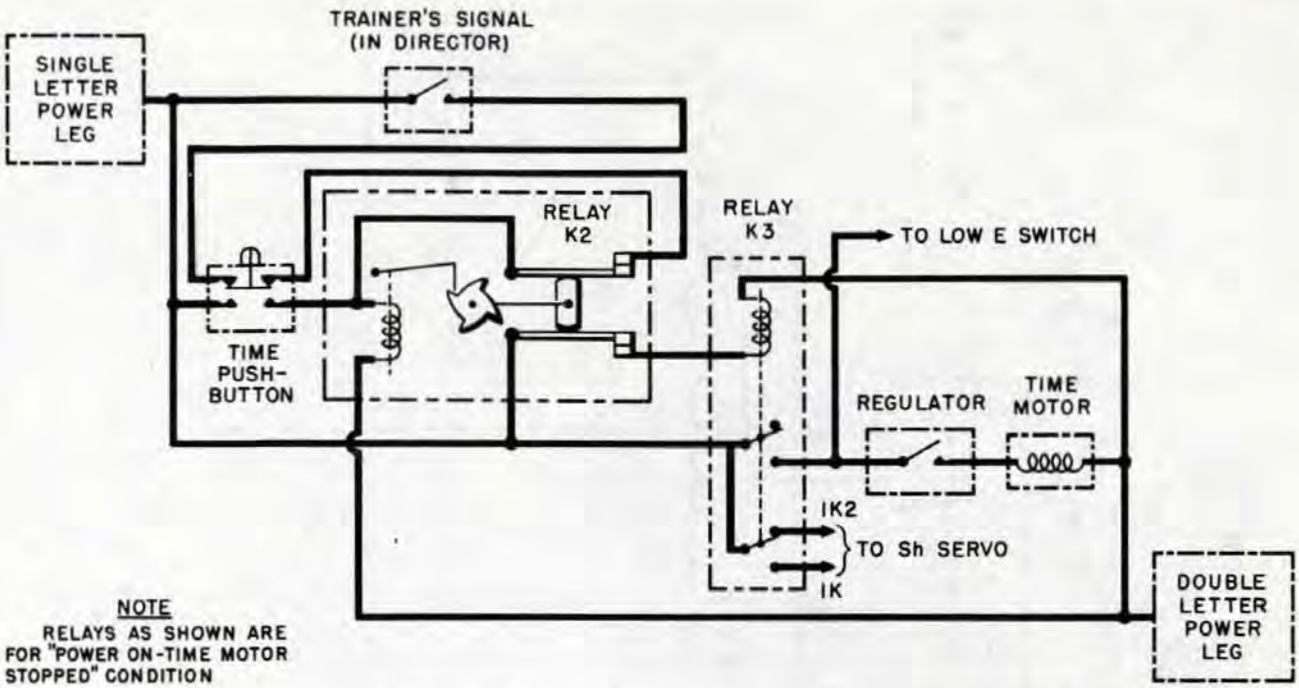


Figure 18. Time Motor Control System

figure 18 ("Power On—Time Motor Stopped" condition).

With the system in the condition shown in the figure, depressing the trainer's signal key starts the time motor in the following manner. The initial effect is to energize the solenoid of relay K2. This actuates the ratchet mechanism of the relay and opens the relay contacts. Since power for the solenoid must come through one pair of the contacts, the solenoid is de-energized, setting the relay for the next cycle of operation. As soon as the relay contacts are opened, the solenoid of relay K3 is de-energized also. This causes relay K3 to close the time motor line to start the time motor.

To stop the time motor, the time motor push button on the computer is depressed. Reference to either figure 17 or figure 18 shows that this energizes the solenoid of relay K2, causing the relay to cycle and restore the condition illustrated in figure 18, wherein the contacts are closed, relay K3 is energized, and the time motor stopped.

The time motor cannot be stopped by means of the trainer's signal key because, in starting the time motor, the contacts of relay K2 were opened, thereby disconnecting this switch from the relay solenoid.

The time motor control system also governs the operation of the *Sh* and the *dH* servo motors in the manner described under the following two headings.

Zeroing *Sh*. Referring to figure 17, it is seen that power for operating the *Sh* servo motor is supplied through either line 1K or line 1K2.

When the solenoid of relay K3 is energized, the relay is actuated to connect line 1K2 to the power supply, while at the same time disconnecting line 1K. Line 1K2 is connected to the left leg of the *Sh* servo motor. Thus when this line is energized, the *Sh* servo motor drives in the decreasing direction; in other words, when the time motor is stopped, *Sh* is set at zero also.

In starting the time motor the solenoid of relay K3 is de-energized. The relay then disconnects line 1K2 from the power supply, connecting line 1K instead. Thus, when the time motor is started, the *Sh* servo motor is again governed by the *Sh* servo control.

Zeroing *dH*. As long as the solenoid of relay K4 is energized, the switch of the relay

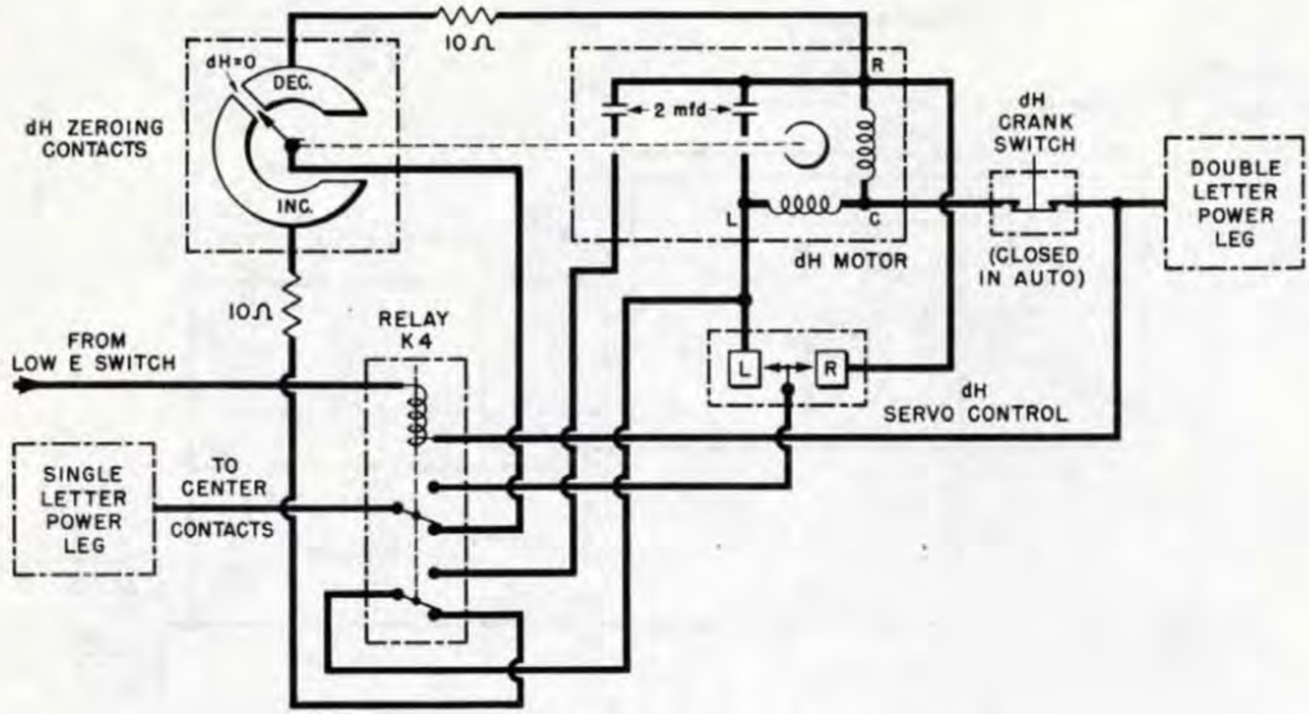


Figure 19. The dH Zeroing System.

will be positioned as shown in figure 17, and operation of the *dH* servo motor will be governed by the *dH* servo control. It is seen in the figure that the power supply to the solenoid is taken from the time motor line and passes through the low elevation switch. Thus, if the time motor control operates to stop the time motor or if the line is opened by the low elevation switch, the solenoid of relay K4 is de-energized and connections to the *dH* servo motor are as indicated in figure 19. The *dH* motor is then controlled by the *dH* zeroing contacts, which cause it to be driven to and held at the zero *dH* position.

These contacts consist of two fixed segments and a rotating contact that is driven by the servo motor. Each segment is connected to one lead of the *dH* servo motor as indicated in the figure. Power is applied through the rotating contact. The connections are such that, when the contacts are in control, the motor drives until it reaches the zero position, at which time the rotating contact is between the two segments. Since connection is then equally to both motor coils, the motor stops running.

Referring to figures 17 and 19 it will be noted that two 2-mfd capacitors are connected in the motor circuit when the relay is set for operation of the *dH* servo control, while when the zeroing contacts are operative one of the capacitors is cut out of the circuit and a 10-ohm resistor is connected in series with each coil of the motor. This arrangement prevents excessive over-travel of the zero point when zeroing *dH*.

The Low *E* Switch

The low elevation switch is a cam-operated double-throw micro switch. The cam is mounted on the elevation transmitter shaft, and the switch is electrically connected as indicated in figure 17. When *E* is greater than 2° the switch is positioned as shown.

When *E* becomes less than 2° the cam moves the switch to the opposite position, thereby de-energizing the solenoids of the target course slew relay and relay K4, and causing a 115 volt, 60 cycle signal to be transmitted to a signal light in the director. The effect of de-energizing the solenoid of relay K4 has already been described. The effect of de-energizing the target course slew relay solenoid is described below.

The Target Course Slew System

The principal purpose of this system is to establish the instrument setting of target angle (*A*) in the proper quadrant as soon as the time motor is started, so that the computer will rate control properly. The component parts of the system are the low *Sh* switch, and the target course slew relay.

The low *Sh* switch. The low *Sh* switch is a micro switch actuated by the *Sh* limit stop (see figure 24). When *Sh* is less than four knots the switch is closed.

The target course slew relay. Figure 17 indicates the manner in which the low *Sh* switch, the target course slew relay, and the *Ct* servo motor are electrically connected. It is seen from the figure that the single letter power input to the *Ct* servo motor passes through the relay. With the low *Sh* switch open, the relay solenoid is de-energized and connections at the relay are as indicated in the figure. This causes operation of the *Ct* servo motor to be under control of the *Ct* follow-up control. When *Sh* is less than four knots the low *Sh* switch is closed, energizing the target course slew relay solenoid. This causes the relay to disconnect the power supply from the *Ct* servo control, and to connect the left lead of the *Ct* servo motor directly to the power supply. The motor then drives until the relay position is reversed, as described below.

Operation of target course slew system. It has been shown in the description of the time motor control system that, when the time motor is stopped, the value of *Sh* applied in the instrument is automatically brought to zero. A study of the rate control mechanism (particularly the component integrators) will show that when the input of target angle (*A*) is more than 90° in error, the mechanism reduces the computed value of *Sh*. Thus, if the input of *A* is more than 90° in error when the time motor is started, the rate control mechanism operates to hold *Sh* at zero, until *A* is positioned less than 90° in error. Under these conditions the target course slew system operates as described in the preceding paragraph, slewing target course (*Ct*), bringing it rapidly to the proper quadrant. As *A* enters this position, the rate control mechanism commences moving *Sh* in the increasing direction. When *Sh* exceeds four knots the low *Sh* switch is opened, the target course slew relay solenoid is de-energized, and operation of the *Ct* servo motor is again governed by the *Ct* follow-up control. If, for any reason, target angle (*A*) is positioned more than 90° in error after rate control has commenced, operation to restore it to the proper quadrant is similar to that described above.

It should be noted here, that it is still possible to slew the *Ct* motor by means of the increase and decrease buttons on the target course indicator (see page 106 of OP 1064), if *Sh* is more than four knots. When operating against surface targets, this operation can be performed when *Sh* is below four knots. It can be seen from figure 17 that when the low elevation switch is positioned for an elevation of less than 2°, the solenoid of the target course slew relay will not be energized, even though the low *Sh* switch is closed. This makes Normal operation against surface targets possible.

Control of Range Input

It has already been stated that when the range rate control switch is at AUTO the range receiver is energized. Thus, range is set into Computer Mk 1A even though the range keeper operator does not indicate he is on target. To make it unnecessary for a computer operator to match the range dials during the target acquisition period, and to prevent erroneous range rates from being generated if the range signal switch is closed before *R* and *cR* are in agreement, relay K1 is provided (see figure 17). It can be seen in the figure that the solenoid of the relay is energized from the island contact of the coarse range receiver motor contact group. When *cR* in the computer is within 700 yards of agreement with the input of range, the solenoid is energized, and the relay switch is positioned as shown. When so positioned, the switch closes two circuits: one connecting the fine range receiver follow-up contact

to the power supply, the other connecting the jdR clutch and range signal switch. Thus, R and cR can be brought into exact agreement, and the jdR clutch can be closed whenever the range signal button is pressed. When the difference between cR and R exceeds 700 yards, the center coarse contact is moved sufficiently from the synchronized position (in which it is shown in the figure) to de-energize the solenoid of relay K1 thus opening the relay. It is then impossible to close the jdR clutch and rate control while the range receiver is out of synchronism. The range finder signal is, however, still operable. Also, the range receiver is then in coarse control only.

Low Range Switch

If rate inputs are set into the rate control computing mechanism when range is less than 1500 yards, erroneous values of target angle and target speed are generated because the $1/cR$ cam has a constant radius below 1500 yards. In Computer Mk 1A a micro-switch is installed to prevent these inputs when R is less than 1500 yards. This switch is connected electrically to the rate control clutches as indicated in figure 17, and is actuated by the carriage of the $1/cR$ cam (see figure 24). When cR passes below 1500 yards the switch is opened preventing the energization of the clutches. Thus, inputs of jE, jBr, and jdR are prevented when range is less than 1500 yards.

PREDICTION SECTION

The material included under this heading in OP 1064 applies generally to the Computer Mk 1A. However, some additional information must be presented in order to cover changes that were made in the Computer Mk 1 since the book was published. These changes were made chiefly in dead time range prediction, initial velocity correction, and in the arrangement of the fuze ballistic computer. Certain other material is included here to cover new modifications of the computer.

It has been shown that, to provide for increased target speed, shaft values in the relative motion and integrator groups were doubled. This causes the inputs of Xo, Yo, Sw, $RdBs$, and RdE to be applied in the prediction section at double the shaft values formerly used in Computer Mk 1. This is desirable in so far as operation of the prediction multipliers is concerned. By doubling the values of the rack inputs to the prediction multipliers the values of the multiplier outputs are doubled; i.e., the full travel of the output rack represents twice the prediction in Mk 1A that it did in Mk 1. This makes it possible to obtain predictions corresponding to the increased target speeds. However, before applying the prediction multiplier outputs to the rest of the prediction mechanism the shafting must be restored to the original value per revolution, otherwise it would be necessary to redesign the rest of the prediction mechanism (including the ballistic cams). This is accomplished by installing halving gear ratios in the multiplier output lines. Beyond the points where these gears are installed, the prediction mechanism shafting moves the same amount as previously for a given change of rate input. The correct numerical values are thus registered on the advance range, sight angle, and sight deflection counters.

The changes made in the relative motion group doubled the value of the $WrD + KRdBs$ shaft lines. To offset the effect of this change, the gearing in the input to the follow-up was changed to restore the follow-up to its former value per revolution. This was necessary because the star shell computer was not affected by the conversion ordalts.

 Table of Contents

Computing Advance Range, *R2*

The description contained in OP 1064 under this heading applies to Computer Mk 1A, with the following exceptions.

The range prediction multiplier. It is stated in the description on page 276 of OP 1064, that the sum of *cR* and *Rt*, as obtained in the range prediction multiplier system, gives an accurate value of advance range (*R2*); when wind is zero the value of *I.V.* applied in the instrument is 2550 fs. This is true only for Mods 8 and 12 of Computer Mk 1A, because these are the only ones having such a value for design *I.V.* The design *I.V.'s* of other mods of Computer Mk 1A are listed under the heading "Initial Velocity" in this addendum. When the *I.V.* set into the instrument corresponds to the design *I.V.* listed for that particular mod, the value of *R2* obtained as described above is correct.

The *Tf* ballistic computer. The following feature, which has the effect of reducing oscillations in *R2*, *F*, and *E'g*, has been incorporated in Computer Mk 1A Mod 13. Without this feature, undesirable oscillations could occur whenever the problem set in the computer involved high negative range rates. The size of the permanently connected capacitor on the *Tf* servo motor has been reduced to one mfd. In addition, a 4-mfd capacitor is provided. This capacitor is connected to the motor through a micro switch, which is actuated by a cam mounted on the comparison differential spider shaft (see figure 24). When the spider is one-third of a revolution from the synchronized position the switch is closed, and the 4-mfd capacitor is cut into the *Tf* servo motor circuit.

The Elevation Prediction Network

The elevation prediction network in Computer Mk 1A Mod 8 and Mod 12 conforms exactly to the description given on pages 282 and 283 of OP 1064 for Computer Mk 1. In Computer Mk 1A Mods 13, 14, 15, and 16 the network is similar to that described in OP 1064, except that the quantity *R2m* is substituted for *R2* as an input to the ballistic computer (see figure 20). The quantity *R2m* is equal to *R2* plus the initial velocity correction *jR2m*, indicated in the figure. This correction is additional to those described under the heading "Initial Velocity" on page 309 of OP 1064. Following is a description of this additional correction.

Correcting *Tf*/*R2*. When using *R2* as an input to the *Tf*/*R2* ballistic cam, as in Computer Mk 1, the output, *Tf*/*R2* contains an error due to the variation of the *I.V.* setting from the value of initial velocity for which the ballistic cams were designed. It should be noted, that a partial correction for this variation has been incorporated in *R2* (see figure 24). The accuracy of the *Tf*/*R2* computation is increased by applying the supplementary *I.V. correction*, *jR2m*, to the *R2* input to the *Tf*/*R2* ballistic computer. An *I.V.* dial and a knob are provided at the front of the computer for the purpose of introducing this supplementary *I.V. correction*. They are indicated schematically in figure 24.

The supplementary correction (*jR2m*) is obtained by means of a gear ratio in the shaft line from the front *I.V.* dial. The quantity *jR2m* is added to *R2* in differential D-91 to produce *R2m*, the altered advance range input to the *Tf*/*R2* ballistic computer (see figures 20 and 24). One branch of the *R2m* shaft line drives the *Tf*/*R2* cam; the other by-passes the cam and is multiplied by a constant *K*, through gearing to produce *KR2m*, which is the straight line approximation of *Tf*/*R2*. The output of the cam

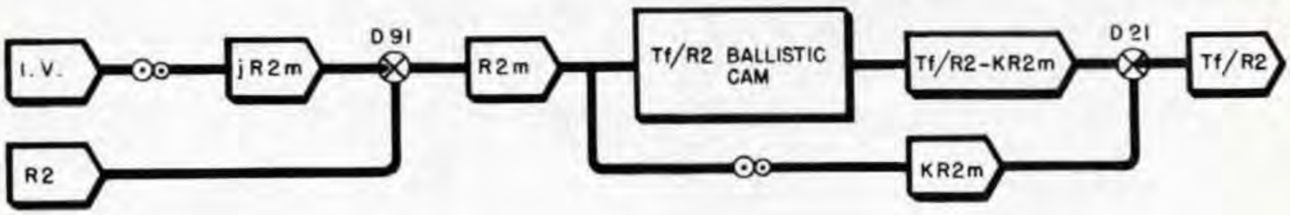


Figure 20. Supplemental I.V. Correction for Tf/R2.

$(Tf/R2 - KR2m)$ is added to $KR2m$ in differential D-21, to produce $Tf/R2$.

The $Vf + Pe$ ballistic computer. In Computer Mk 1A Mod 13 only, with $Vf + Pe$ ballistic computer follow-up is provided with a capacitor and micro switch arrangement similar to that just described for the Tf ballistic computer follow-up (see figure 24). The purpose of this is to further reduce oscillations of the gun elevation order output. The only difference between the two arrangements is that the switch actuating cam of the $Vf + Pe$ follow-up is designed to cut in the 4-mfd capacitor immediately upon any movement from the synchronized position, rather than after approximately one-third revolution of the cam shaft.

Computing Sight Deflection, *Ds*

The description contained under this heading in OP 1064 (page 286) is applicable to Computer Mk 1A, except that where reference is made to 2550 *I.V.*, the design *I.V.* of the particular mod should be substituted.

Computing Fuze Setting Order, *F*

The following description of the computation of fuze setting order (F), rather than that given in OP 1064, should be applied to Computer Mk 1A.

The fuze of a projectile must be so timed that the projectile will burst at the predicted target position. If the fuze could be set in the gun at the instant the projectile is fired, the fuze setting order (F) would be equal to the value of time of flight (Tf) corresponding to the current value of advance range ($R2$). But since the fuze must be set several seconds before the projectile is fired, the fuze time must equal time of flight corresponding to the value that advance range will have at the time the fuzed projectile is fired. The elapsed time between setting the fuze and firing the fuzed projectile is dead time (Tg). The value that advance range will have at the end of dead time is called fuze range ($R3$).

In the instrument, fuze range ($R3$) is determined by computing the change in advance range during dead time (RTg), and then adding RTg to the current value of $R2$. Thus,

$$R3 = R2 + RTg$$

It should be noted here that, as range changes during time of flight, and the difference in the amount of this change during Tg must be accounted for, the value of RTg derived in the instrument includes a compensating factor for this difference.

Computing fuze range. The change in advance range during dead time can be determined from the quantities that make up advance range ($R2$) and fuze range ($R3$). $R3 = cR + (dR{+}dRxe)\ Tg + (dR{+}dRxe)\ F + Rw + (I.V.\ Correction)$, and $R2 = cR + (dR{+}dRxe)\ Tf + Rw + (I.V.\ Correction)$. Transposing the formula of the preceding paragraph we have:

$$RTg = R3 - R2$$

Subtracting the equation for $R2$ from that for $R3$ we have:

$$RTg = [(dR{+}dRxe)Tg] + [(dR + dRxe)(F - Tf)].$$

The quantity $[(dR + dRxe)Tg]$ is the actual range change during Tg, and the quantity $[(dR + dRxe)(F - Tf)]$ the compensating factor for the difference in range prediction mentioned in the previous paragraph.

In the instrument solution, RTg is computed in the dead time prediction multiplier. (See figure 21.) As can be seen from the preceding paragraph, the equation on which the computation is based is: $RTg = (dR + dRxe)(Tg + F - Tf)$. Because of mechanical considerations, the factor $(dR + dRxe)$ is not used as an input to the multiplier. Instead, its equal $(dRs - dRm)$ is used. It is explained in the "Initial Velocity" section of OP 1064 that the corrected value of range rate is:

$$dRs = dR + dRxe + dRm,$$

where dRm is a correction for initial velocity. Subtracting dRm from both sides of the equation:

$$dRs - dRm = dR + dRxe$$

Gene Slover's US Navy Pages

Table of Contents

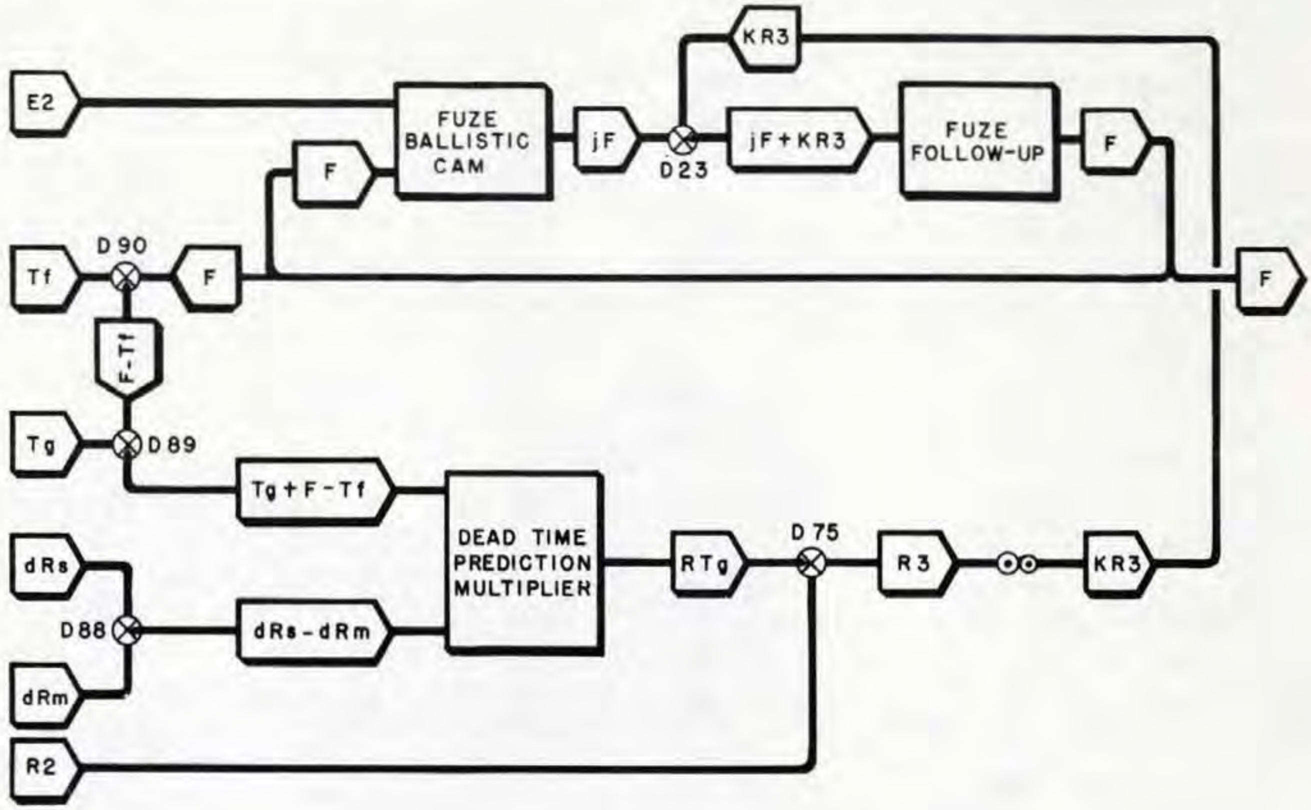


Figure 21. Fuze Computation Network.

From this, the formula for the instrument solution of RTg becomes:

$$RTg = (dRs - dRm)(Tg + F - Tf)$$

The subtraction of dRm from dRs is accomplished in differential D-88. The output of D-88 positions the input rack of the dead time prediction multiplier. Time of flight (Tf) is subtracted from fuze time (F) in differential D-90, and the difference is added to dead time (Tg) in differential D-89 resulting in ($Tg + F - Tf$), which becomes the input to the screw of the multiplier. The output of the multiplier is RTg.

The quantity, RTg, is added to advance range ($R2$) in differential D-75, producing fuze range ($R3$). The latter quantity is then used in the fuze ballistic computer to compute fuze setting order (F).

The fuze ballistic computer. The computation of fuze setting order is made in the following manner. Fuze range is multiplied by a constant (K) through gearing to produce the straight line approximation of fuze time ($KR3$). The quantity, $KR3$, drives through differential D-23 (figure 22) and offsets the contacts of the fuze follow-up control, causing the servo motor to rotate the cam of the fuze ballistic computer. The cam follower, which is also positioned axially by predicted target elevation ($E2$), puts out partial fuze setting order (jF). This supplies the second input to differential D-23. The output of D-23 then becomes the sum of $KR3$ and jF, or fuze setting order (F), which is amplified in torque by the fuze follow-up. The output of the fuze servo motor positions the fuze setting order transmitter, and acts regeneratively by supplying inputs to the fuze cam and to the dead time prediction multiplier. The use of the fuze servo motor to rotate the fuze cam relieves the load on the dead time prediction multiplier and other mechanisms.

Initial Velocity

The description given in OP 1064 (page 308) under the heading "Initial Velocity" is applicable to Computer Mk 1A if it is borne in mind that, wherever the value 2550 fs appears, it refers to the design *I.V.* of the instrument. Only Mods 8 and 12 have a design *I.V.* of 2550 fs. In applying the description to other mods, the appropriate values should be substituted.

Mods 13, 14, 15, and 16 contain a supplementary initial velocity correction to $Tf/R2$. It has already been described in this addendum under the heading, "The Elevation Prediction Network."

SPOTS

The description under the heading SPOTS given in OP 1064 (page 312) is applicable to the Computer Mk 1A. In the case of Mods 8 and 12, however, additional information is necessary since these mods are designed to permit firing at surface targets beyond the maximum value of the advance range limit stop by a system of elevation spots.

Elevation Spot for Surface Fire

Mods 8 and 12 compute superelevation in the same manner as other mods for values of advance range within the limits of 500 and 20,000 yards. Since 5"/54 cal. guns to which Mods 8 and 12 apply have extreme ranges exceeding 20,000 yards at low position angles (target elevation, E), it might be desired to fire at surface targets at these longer ranges. In such a case, computed superelevation will stop at the value corresponding to 20,000 yards advance range. The additional superelevation necessary is introduced as an UP elevation spot (Vj). This acts to increase gun elevation order. To aid in computing the magnitude of spot required, a transparent dial is superimposed on the elevation spot dial. (See figure 8.) This dial is calibrated in yards range, from 20,000 to 24,600. In operation, the elevation spot knob is turned until the overlay dial indicates the value of advance range, which, in such a case, must be determined independently of the computer. Range graduations on the overlay dial are spaced so that the value of the spot input will equal the additional superelevation required above 20,000 yards. The 20,000-yard graduation is aligned directly over the zero graduation of the Vj dial. Although the graduations for ranges greater than 23,500 overlay the DOWN graduations on the Vj dial, they have no meaning unless they have been brought to the fixed index by application of an UP spot.

Gun Orders

The description on gun orders given in OP 1064 (page 324) is applicable to Computer Mk 1A. However, Computers Mk 1A Mods 14, 15, and 16 transmit values of gun train order information in addition to the quantities covered in OP 1064.

This quantity is transmitted by a single, 10-degree per revolution, 7G synchro generator. The transmitter is equipped with a dial that has a single index mark engraved on it. The index, when matched against a fixed index, indicates the electrical zero position of the transmitter. Values of gun train order ($B'gr$) position the transmitter, which transmits these values to the multiple turret indicators.

THE SYNCHRONIZE ELEVATION GROUP

The description of the synchronize elevation group of Computer Mk 1 given in OP 1064 is applicable to Computer Mk 1A with the following addition.

The Elevation Transmitter

Computer Mk 1A (all mods) also transmits the value of target elevation (E). It is transmitted in two ways, by a synchro gen-

erator and by a potentiometer. The output of the potentiometer is used in conjunction with Radar Equipment Mk 25 Mod 2 for stabilizing a scope presentation on Radar Indicator Mk 22 Mod 0 with the display selector in the ΔE position. The synchro signal is available for later use in target practice analysis and for indication in Elevation Indicator Mk 6, in the director, if required.

PARALLAX

The description under the heading "PARALLAX" in OP 1064 is applicable to Computer Mk 1A with the exceptions given below.

Computer Mk 1A Mod 15 does not compute parallax in elevation due to a horizontal base (*Pv*). Instead, it computes another parallax quantity, parallax range, described below. With the omission of the *Pv* computation in Mod 15, a cosine output rack is not required in the parallax component solver and is therefore omitted.

Parallax Range

The Computer Mk 1A Mod 15 computes parallax range. This is a factor in the computation of the parallax correction that must be applied to gun train order to correct gun train for the horizontal base between the reference point and the gun. Since the train parallax computer provides *Ph* for the directors, another mechanism is needed to compute *Ph* for the guns. Such a mechanism is located at each gun. However, the Computer Mk 1A aids the computation by supplying one factor, namely, parallax range, equal to $sec\frac{(E2+L)}{R2}$. Transmitted to the guns, this quantity is then multiplied by sin $B'gr$ and the applicable constants to produce the required parallax correction.

In computing parallax range, the train parallax computer supplies sec $(E2+L)$, which is multiplied by $1/R2$ in the parallax range computer (see figure 22). The parallax range computer is a single-cam computing multiplier. The cam is positioned by advance range ($R2$) and computes $1/R2$. The input rack is positioned by sec $(E2+L)$ supplied by the train parallax computer. The output of the parallax range computer is $\frac{\sec(E2+L)}{R2}$.

Parallax range is transmitted to the guns by a single-speed transmitter. The transmitter dial is graduated in yards, from 1500 to infinity. The space between graduations varies inversely with advance range; that is, as the range increases the space between graduations decreases (see figure 23). This

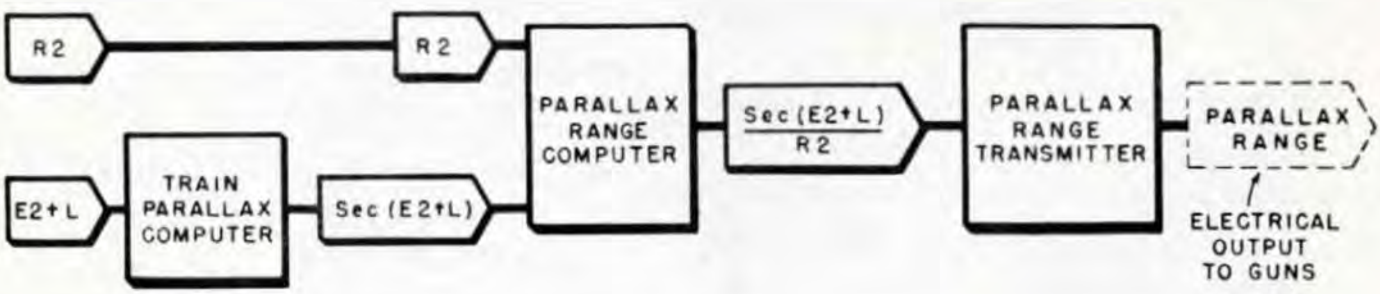


Figure 22. Parallax Range Network.

dial is used for test purposes only, the infinity mark indicating electrical zero of the transmitter, and a white dot on the dial (see figure 23) being used when adjusting the parallax range computer. The range graduations are used to test the accuracy of the instrument computations, *E2* and *R2* being set in the computer and the resulting value of parallax range being read on the dial.

Elevation Parallax Correction, *Pe*

The vertical base for the computation of elevation parallax correction (*Pe*) for the various modifications of Computer Mk 1A is as follows:

Mods 8, 13, 15	30 feet
Mod 12	55 feet
Mod 14	40 feet
Mod 16	15 feet
Mod 17	39 feet
Mod 18	0 feet
Mod 19	20 feet

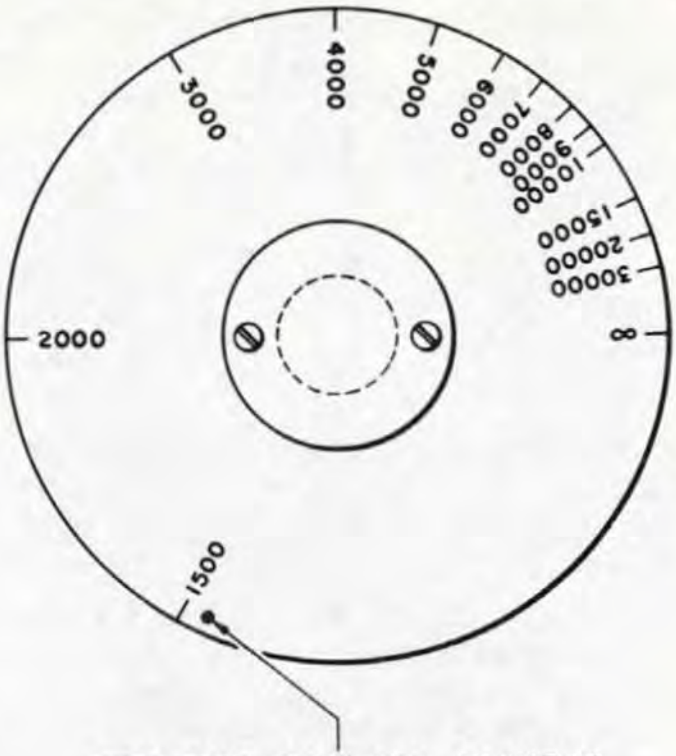


Figure 23. Parallax Range Dial.

MOD DIFFERENCES

Serial Numbers

The code used in assigning serial numbers to Computers Mk 1A indicates where the instrument was modernized, as follows:

SERIAL NUMBERS	MODERNIZED BY
1001 to 1699	Ford Instrument Company, Division of The Sperry Corporation
1700 to 1799	Mare Island Naval Shipyard
1800 to 1826	New York Naval Shipyard
1900 to 1925	Naval Gun Factory

Note: Serial numbers 2001 and up designate computers Mk 1 which were manufactured by the International Business Machines Corporation.

List of Fordalts

The list of Fordalts given on pages 388 and 389 of OP 1064 should be supplemented by the following:

FORDALT

192—Increases limits of *E*, and adds *F* intermittent drive.

193—Disconnects (*T*/*cR*) sec *E* counter drives.

194—Replaces fabricated cover for sensitivity unit with a cast cover.

195—Redesigns 5-inch integrator to restrain carriage from rocking in the direction of travel.

199—Converts Mk 1 Mod 6 (Serial No. 101 to 215) to Mk 1A Mod 13.

200—Alters Ordalt 2331 into 2331A to provide adjustable smoothing of solution data for surface fire control.

201—Redesigns 5-inch integrator to strengthen ball retaining studs, and to provide finer adjustment of horizontal rollers.

202—Redesigns 5-inch integrator to align integrator carriage correctly.

206—Converts two Computers Mk 1 Mod 8 and two Computers Mk 1 Mod 12 to Mk 1A Mod 17.

221—Converts Computer Mk 1 Mod 13 to Computer Mk 1A Mod 19.

List of Ordalts

The list of Ordalts given on page 390 of OP 1064 should be supplemented by the following:

ORDALT

2331A—Provides target vector rate control system (Mods 8, and 12 to 16).

2332—Increases limits of *Sh*, *So*, *Sw*, *dH*, *dR*, *dRh*, *RdE*, and *RdBs* (Mods 8, and 12 to 16).

2336—Provides for the transmission of *E* from both a potentiometer and a synchro generator (Mods 8, and 12 to 16).

2338—Changes, by replacement, *I.V.* dial under cover No. 3 (Mods 0 to 7, 9, 10, and 13).

2339—Replaces ballistic cams to incorporate new 5″/38 cal. data as compiled in OP 551A (Mods 0 to 7 and 13).

2612—Alters Star Shell Computer Mk 1 Mod 2 by replacing 6DG synchro generators with 6G synchro generators.

2614—Provides for aleration of Mods 8, 13, and 14 instruments for use in AG128: On Mods 8 and 14, by replacement of dip dial and $Vf + Pe$ cam; on Mod 13, by replacement of dip dial and all ballistic cams.

2620—Installs micro-switch on $1/cR$ cam to open rate control clutch circuits below 1500 yards (all mods).

2626—Incorporates operating control circuit changes which provide for:

1. Starting time motor automatically.
2. Automatically matching generated and observed range dials when range rate control switch is at AUTO.
3. Elimination of the requirement for an initial estimate of target motion (Mods 8, 12, 13, and 15).

2694—Provides *Pe* for vertical base of 55 feet and dip correction for 100 feet director height (six Mod 12 instruments only — two each on CVB 41, 42, and 43).

2894—Reduces oscillations in *R2*, *E′g*, and *F* (Mod 13 only).

2918—Removes limit stop L-36 (Mods 8, and 12 to 16).

2963—Same as Ordalt 2626 (for Mods 14 and 16 only).

3091—Changes time switch and removes target speed (Mods 8, and 12 to 16).

Table of Modification Differences

Information concerning modification differences of Computer Mk 1A Mod 8, and Mod 12 through Mod 19 is given in tabular form on the following pages. This information corresponds to that given on pages 399 and 399A of OP 1064 for Computer Mk 1.

It should be noted here that Computer Mk 1A Mods 17 and 19 are for use in Gun Fire Control System Mk 67. They therefore differ from the other modification in more ways than can be indicated in the tables. Reference should be made to OP 1064G Computer Mk 1A Mods 17 and 19 for further information on these modifications.

TABLE OF MODIFICATION DIFFERENCES

MISCELLANEOUS

MOD NUMBER	8	12	13	14	15	16	17	18	19
Gun	5″/54	5″/54	5″/38	6″/47	8″/55	6″/47	5″/54	5″/54	5″/38
Pe Base	30 ft.	55 ft.	30 ft.	40 ft.	30 ft.	15 ft.	39 ft.	0	20 ft.
Dip Base	22 yd.	13 yd.	17.83 yd.	70 ft.	59 ft.	45 ft.	Variable		Variable
Parallax Driven By	Either by *B′gr* or *B′r* Selected by A-242								
Star Shell Computer	Mk 1 Mod 2	Mk 1 Mod 2	Mk 1 Mod 0 or 1	Mk 1 Mod 3	None	Mk 1 Mod 3	Mk 1 Mod 4	Mk 1 Mod 2	Mk 1 Mod 6

LIMITS

	8	12	13	14	15	16	17	18	19
Present Range	0 35,000 yd.								
Advance Range (yd.)	500 20,000	500 20,000	500 18,000	500 20,200	500 20,000	500 20,200	500 20,000	500 20,000	500 18,000
Target Height	0 50,000 ft.								
Range Spot	IN 12,000 yd. OUT 1800 yd.								
Mech. Fuze (sec.)	0.60 49.00	0.60 49.00	0.60 55.00	0.60 49.00	0.60 49.00	0.60 49.00	0.60 49.00	0.60 49.00	0.60 55.00
Time of Flight (sec.)	0.60 50.60	0.60 50.60	0.60 60.60	0.60 50.60	0.60 50.60	0.60 50.60	0.60 50.60	0.60 50.60	0.60 60.60
Ship Speed	0 90 kn.								
I.V. (ft/sec.)	2400 2650	2400 2650	2350 2600	2250 2720	2400 2700	2250 2720	2400 2650	2400 2650	2350 2600

TABLE OF MODIFICATION DIFFERENCES (*Continued*)

LIMITS (*Continued*)									
MOD NUMBER	8	12	13	14	15	16	17	18	19
Elevation Spot (mils)	UP 342.5 DOWN 180	UP 342.5 DOWN 180	UP 180 DOWN 180	UP 180 DOWN 180	UP 180 DOWN 180	UP 180 DOWN 180	UP 342.5 DOWN 180	UP 342.5 DOWN 180	UP 180 DOWN 180
Elevation	−25° +85°								
INTERMITTENT DRIVES									
Ds	None	None	320 680	None	390 590	None	None	None	None
Vs	None	None	2000 3800	None	2000 4460	None	None	None	None
cR	750 yd. 22,500 yd.								
E	−2° +85°								
R2 (yd.)	1500 18,900	1500 18,900	None	1500 18,900	1500 18,900	1500 18,900	1500 18,900	1500 18,900	None
RECEIVERS									
So	40.0 kn.								
R	2000 yd. and 72,000 yd.								
$L+\frac{Zd}{30}$ Shaft	Provided						None	Prov.	None

TABLE OF MODIFICATION DIFFERENCES (*Continued*)

<table>
<tr><th colspan="10">TRANSMITTERS</th></tr>
<tr><th>Mod Number</th><th>8</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th></tr>
<tr><td>Train Parallax</td><td colspan="6">7G's 30°</td><td>5HG's
10°
360°</td><td>7G
30°</td><td>5HG400
30°</td></tr>
<tr><td>Elevation Parallax</td><td colspan="4">7G's 10°</td><td>None</td><td>7G
10°</td><td>5HG's
10°
360°</td><td>7G
10°</td><td>None</td></tr>
<tr><td>Parallax Range</td><td colspan="4">None</td><td>7G
0.001</td><td>None</td><td>None</td><td>None</td><td>None</td></tr>
<tr><td>Sight Angle</td><td colspan="2">7G's
200′
7200′</td><td>6G's
2400′
200′
7200′</td><td>7G's
200′
7200′</td><td>7G's
100′
3600′</td><td>7G's
200′
7200′</td><td>18CX4's
1-speed
36-speed</td><td>7G's
200′
7200′</td><td>5HG400's
200
7200</td></tr>
<tr><td>Sight Deflection (Mils)</td><td colspan="2">7G's
100
4000</td><td>6G's
442.24
100
4000</td><td>7G's
100
4000</td><td>7G
210.48</td><td>7G's
100
4000</td><td>18CX4's
1-speed
36-speed</td><td>7G's
100
4000</td><td>5HG400's
100
4000</td></tr>
<tr><td>Fuze (sec.)</td><td colspan="4">7G's
2
100</td><td>7G's
20/7
360/7</td><td>7G's
2
100</td><td>5HG's
72/7
360/7</td><td>7G's
2
100</td><td>5HG400's
2
100</td></tr>
<tr><td>Elevation & Bearing Correction</td><td colspan="6">6G's — 5° Auto.
5G's — 10° Ind.</td><td>5G's
10°</td><td>6G's
5°
5G's
10°</td><td>5G's
10°</td></tr>
<tr><td>B'gr Information</td><td colspan="3">None</td><td colspan="3">7G's 10°</td><td>None</td><td>None</td><td>None</td></tr>
</table>

COMPARATIVE INDEX

Index of Pages in OP 1064, wherein description does not accurately cover Computer Mk 1A, and corresponding pages in Addendum covering differences.

OP 1064 Page	OP 1064 Addendum No. 1 Page	Remarks
12, 13	2	Basic Mechanisms.
22, 23	3	Types of Targets and Attack.
24	3	Variation in determination of target motion rates.
28, 29, 30	3	Tracking.
50 to 55	3	The Rate Control Group.
56 to 61	4, 5	Rate Control. Also see Detailed Description of rate control in Addendum.
67	5	Parallax.
68, 69	5	Star Shell Computer — additional mods.
70, 71	5	Additional Outputs.
72 to 75	6 to 13	Operating Limits.
77	14	Design *I.V.*
80	15	Operating Controls
84, 85	15	
86	15	
87	15	
92	15, 17	
93	17	
94 to 101	17, 18	No Semi-Auto. Ordalt 2626 changes.
104	18	Use of *Vj* spot for ranges beyond 20,000 yards on Mods 8, 12.
106	19	Signal light omitted.
107	19	
110 to 113	20	No Semi-Auto.
114, 115	20, 21	
116 to 137	21, 22	
142	22	
156, 157	22	
172 to 201	23, 24	Values of speed and related lines only.
202 to 265	24 to 46	Rate Control
268 to 269	46	Shaft Values
276	47	Design *I.V.* of particular mod must be applied.
277	47	*Tf* ballistic computer.
282, 283	47	*R2m* input to *Tf/R2* ballistic cam.
285	48	*Vf* + *Pe* ballistic computer.
286, 287	48	Design *I.V.* not 2550 fs for all mods.
288, 289	48, 49	Fuze
290, 308, 309, 310	50	Design *I.V.* not 2550 fs for all mods.
312	50	Elevation spots for long range surface fire (Mods 8, 12).
324	50	Gun Train Order Information (Mods 14, 15, and 16).
332	50, 51	Elevation Transmitter.
338 to 351	51	Parallax Range; Vertical Parallax Base.

This Page is Blank

2

RESTRICTED

OP 1064 A
VOLUME 1

COMPUTER MARK 1 AND MODS.

MAINTENANCE

DEPARTMENT OF THE NAVY
BUREAU OF ORDNANCE

A BUREAU OF ORDNANCE PUBLICATION

VOLUME 1

COMPUTER MARK I AND MODS

MAINTENANCE

DEPARTMENT OF THE NAVY BUREAU OF ORDNANCE

NAVY DEPARTMENT

BUREAU OF ORDNANCE

WASHINGTON 25, D. C.

18 July 1947

RESTRICTED

ORDNANCE PAMPHLET 1064A

COMPUTER MARK 1 AND MODS MAINTENANCE

1. Ordnance Pamphlet 1064A contains information on the tests, trouble shooting analysis, repairs and maintenance procedures for the Computer Mark 1. The contents are presented in two volumes, and the procedures described therein may be performed aboard ship.

2. This pamphlet is intended for use of shipboard maintenance personnel and should be used in conjunction with NavOrd Form 1229 Computer Mark 1 Log Book.

3. This pamphlet supersedes the following publications:

NavOrd OD 3133 (Revision A)
NavOrd OD 3137
NavOrd OD 3139
NavOrd OD 3140 (Revision B)
NavOrd OD 3180
NavOrd OD 3181
NavOrd OD 3183
NavOrd OD 3184 (Revision A)
NavOrd OD 3185 (Preliminary)
NavOrd OD 4174 (Revision C)
NavOrd OD 4186
NavOrd OD 5157

Ordnance Pamphlet 1453 (Preliminary)

Additional information may be found in:

OP 1064	Computer Mark 1 and Mods
OP 1064C	Star Shell Computer Mark 1 Mods 0, 1, 2, and 3.
OP 1064D	Computer Mark 1 Mods 8 and 12
OP 1064E	Computer Mark 1 Mods 14 and 16
OP 1064F	Computer Mark 1 Mod 15

4. This publication is RESTRICTED and should be handled in accordance with Article 76, U.S. Navy Regulations, 1920.

G. F. HUSSEY, Jr.
Vice Admiral, U. S. Navy
Chief of the Bureau of Ordnance

CONTENTS

VOLUME ONE

VOLUME TWO

INTRODUCTION

Ordnance Pamphlet 1064A contains information necessary for the maintenance of Computer Mark 1. Since the majority of these instruments that are in service are either Mod 7 or 13, this book is written primarily for the Computer Mark 1 Mod 7 or Mark 1 Mod 13, equipped with a Star Shell Computer Mark 1, a Selector Drive Mark 1, and a Target Course Indicator Mark 1. However, sufficient information is given to cover the older instruments also, namely Mods 0, 1, 2, 3, 4, 6, 9, and 10. Maintenance information for other mods is contained in companion publications as follows: OP 1064D, Mods 8 and 12; OP 1064E, Mods 14 and 16; and OP 1064F, Mod 15. Maintenance of the Star Shell Computer Mark 1 Mods 0, 1, 2, and 3 is covered in OP 1064C. Information for the complete overhaul of Computer Mark 1 is contained in OP 1064B.

Since the information covered by this publication, OP 1064A, is extensive, two volumes are required. The division into volumes is of no significance other than for ease in handling.

The following summary of the various sections of the book will serve to indicate the material covered.

PART 1—TESTS

Detailed instructions are given for setting up, running, and recording the results of all the standard tests required to check computer operation. This section serves as an adjunct to the test procedure given in the Computer Mark 1 Log Book, NAVORD Form 1229.

PART 2—ANALYSIS OF TEST ERRORS

For each type of test, methods are given for locating the causes of errors, together with the procedure to be followed in correcting them.

PART 3—UNIT CHECK TESTS

Special tests and detailed instructions for performing them are given in order to identify the seat of trouble in a computer that is not operating properly. These tests serve as a reference to be used while analyzing errors in the A and B tests.

PART 4 – READJUSTMENT PROCEDURE

All of the adjustment points in the computer are listed in numerical order for quick reference. For each adjustment the location, method of checking, and steps necessary for readjustment are given. This information will be of value in the course of correcting test errors or after disassembly and reassembly of part of the instrument.

PART 5 – LOCATING CASUALTIES

The more common sources of mechanical or electrical trouble are listed for reference in trouble analysis. Methods are given for correcting these troubles. Descriptive and maintenance information is given for some of the special units used in the Computer Mark 1 which are not covered elsewhere.

PART 6 – LUBRICATION

Information is given for the selection of suitable lubricants and for the proper methods of using them.

PART 7 – REMOVAL OF MECHANISMS

Instructions are given for use in the removal and replacement of any unit, or subassembly, of the computer. This information will be of value if a casualty occurs and a unit must be removed for bench repair.

PART 8 – FACTORY ADJUSTMENT PROCEDURE

Detailed information is given for complete adjustment of the computer after a major repair job or after the entire instrument has been disassembled and reassembled.

PART 9 – SKETCH LISTS

Drawing numbers of all units in the computer are listed so that the proper drawings may be ordered for reference while repairing a unit.

In order to obtain the fullest benefit from the information covered in this OP, it is essential for the maintenance man to have first-hand knowledge of the general nature and operation of the Computer Mark 1, as covered in OP 1064. Also, he must have, as a background, considerable experience in basic repair operations and basic mechanisms maintenance, as covered in OP 1140A. Although an attempt has been made to keep each part of the presentation as simple and direct as possible, the complexity of the mechanism requires such a background as a preliminary to understanding its maintenance.

Part one

TESTS

Introduction

This section deals with the various, periodically conducted tests of the Computer Mk 1 and the Star Shell Computer Mk 1. The primary purpose of these tests is to check the functional accuracy of the computing mechanism and transmission system. When the experienced operator runs the tests, he will also be able, by the feel of the input handcranks, or by the sound of the instrument, to detect any variation from normal. Such a variation might indicate potential trouble even though the test results at that time were satisfactory.

In order to perform these duties effectively, the test operator should have special kinds of experience. Primarily, he should be familiar with the operation and function of the computer. Although the instructions for running tests are explicit enough to enable even inexperienced personnel to set up the problems and read the results, such personnel would not be able to analyze the results properly or to decide whether the computer was operating satisfactorily in every respect. In order to run the tests intelligently, the operator should be thoroughly familiar with typical operation, as well as with the functions of the internal mechanisms, as described in OP 1064 and OP 1140. Also, he should be familiar with the instrument itself, and the sections in this OP dealing with *Analysis of Test Errors*, and *Locating Casualties*. Familiarity with the instrument involves knowing the location, function, and "feel" of each handcrank, the location and calibration of each dial and counter, and the sound of the instrument. Also, it involves knowing that precision in making settings and readings is necessary for producing consistent test results. Familiarity with the material under *Analysis of Test Errors* and *Locating Casualties* will enable the operator quickly to recognize symptoms of trouble which might damage the mechanism if operation were continued. Also, if the test errors become excessive, the operator will be able to decide whether the test should be continued to gain further information, or whether corrective measures should be taken immediately.

The test instructions given in this section are merely illustrative or descriptive of the operations necessary to run each type of test. For the time table of tests, and the necessary problem setup and record forms, refer to the Computer Mk 1 Log Book, NAVORD Form 1229. In addition to the periodic tests called for by the time table, a complete set of tests should always be run after any repair or readjustment.

In tests requiring a record to be kept, the results should be recorded and the errors computed before the next problem is set up. After a complete set of test problems has been conducted, the over-all average and maximum errors should then be computed. If excessive errors occur in a single problem, the error calculations and the problem result readings should be checked. Also, the problem should be completely reset to eliminate the possibility of an originally faulty setup. This does not mean bringing the quantities on from the other direction. The errors should be within the allowable limit regardless of which way the quantities are brought on.

Throughout the tests, computation of error follows the universally used procedure based on the definition of an error. By definition, an error equals the observed reading minus the calculated value of the quantity under observation. It should be noted that the operation indicated by the word "minus" is one of *algebraic subtraction.* The following table of examples will serve to make this clear:

Calculated Value	*Observed Reading*	*Error*
49°50′	49°52′	+2
49°50′	49°49′	−1
−0°11′	−0°13′	−2
−0°11′	−0°08′	+3

It is highly important that the method of computing error be thoroughly understood and followed because it forms the basis for the reasoning in the chapters on *Analysis of Test Errors.*

A Test

The A test provides a static check of all the computing mechanisms in the instrument. For each problem, a particular setup is made and the resulting values of the output quantities are read.

Star Shell A Test

The star shell A test checks the computing mechanisms of the star shell computer and also the mechanisms of the Computer Mk 1 which supply mechanical inputs to the star shell computer.

On the Mod 0 instruments, the gun order dials are behind the front cover. As an alternative to removing this front cover every time a star shell A test is run, an approximate reading may be obtained by transmitting star shell gun orders to a gun mount and reading the problem results there.

B Test

Primarily, the B test checks the integrator group in the computer. The relative motion component solvers, except the ship and target vector gears, also are checked by the B test. Since, in the B test, the ship and target vector gears, when corresponding speeds are above zero, are at the angular position for maximum output, small errors in their angular position will not affect the results significantly.

In order to conduct an accurate test, and to obtain consistent results, the setup must be made with extreme care. This is especially true of the short range settings in the bearing B test. Also, when running repeated tests for purposes of refining the adjustments, it is usually desirable to bring the input values onto their settings from the same direction each time. However, the instrument should be so adjusted and the lost motion in the gear train sufficiently small that the test errors are within the allowable value regardless of the direction of setup.

C Test

The C test is a factory test which normally is not run on shipboard. Problems in the first group are run in LOCAL control and may be run at any time. Those in the second group are run in SEMI-AUTO control and require a special cable connection to make the computer regenerative. A substitute check for this second group may be run by connecting the computer with the director.

The C test checks the tracking section which is made up of the relative motion group and the integrator group. Unlike the A and B tests, in which constant input values are used, the C test uses constantly changing inputs similar to the actual tracking problem. The C test is unlike the actual tracking problem in that these input values are permitted to build up errors instead of being constantly corrected by rate control.

Rate Control Test

The rate control tests check the mechanisms in the rate control section. The *jE* and *jBr* solenoid clutches and follow-up motors are checked only in the AUTO rate control test. Specified corrections to generated range, generated elevation, and generated bearing are introduced into the rate control mechanisms, and should result in specified changes in *A*, *Sh*, and *dH*.

Transmission Test

The transmission test is one of the most important checks of the fire control system. This test consists of checking each receiver and each transmitter for accuracy throughout the limits of its operation. The test should be made for each possible switchboard combination.

The experienced operator will be able to check transmission in a much shorter time by means of a combination of special tests. Such tests are the receiver synchronization test, the round robin test, and the over-all test. If any error occurs or if there is any doubt of the correct operation of a unit, the complete transmission test of that unit should be performed.

The transmission test for the Star Shell Computer Mk 1 Mod 0 may be run by transmitting star shell A-test results to the gun mounts. If excessive errors occur, the front cover should be removed and the regular transmission test run.

Time Motor Regulator Test

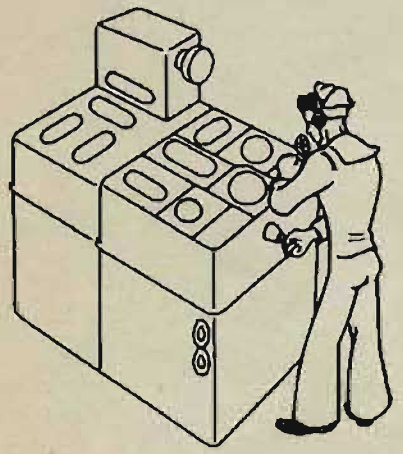
The time motor regulator test is a stop watch check on the speed of the time line.

Table of Operating Limits

The table of operating limits provides a check list of all limit stops and intermittent drives in the instrument. These limits should always be checked after any repair or readjustment.

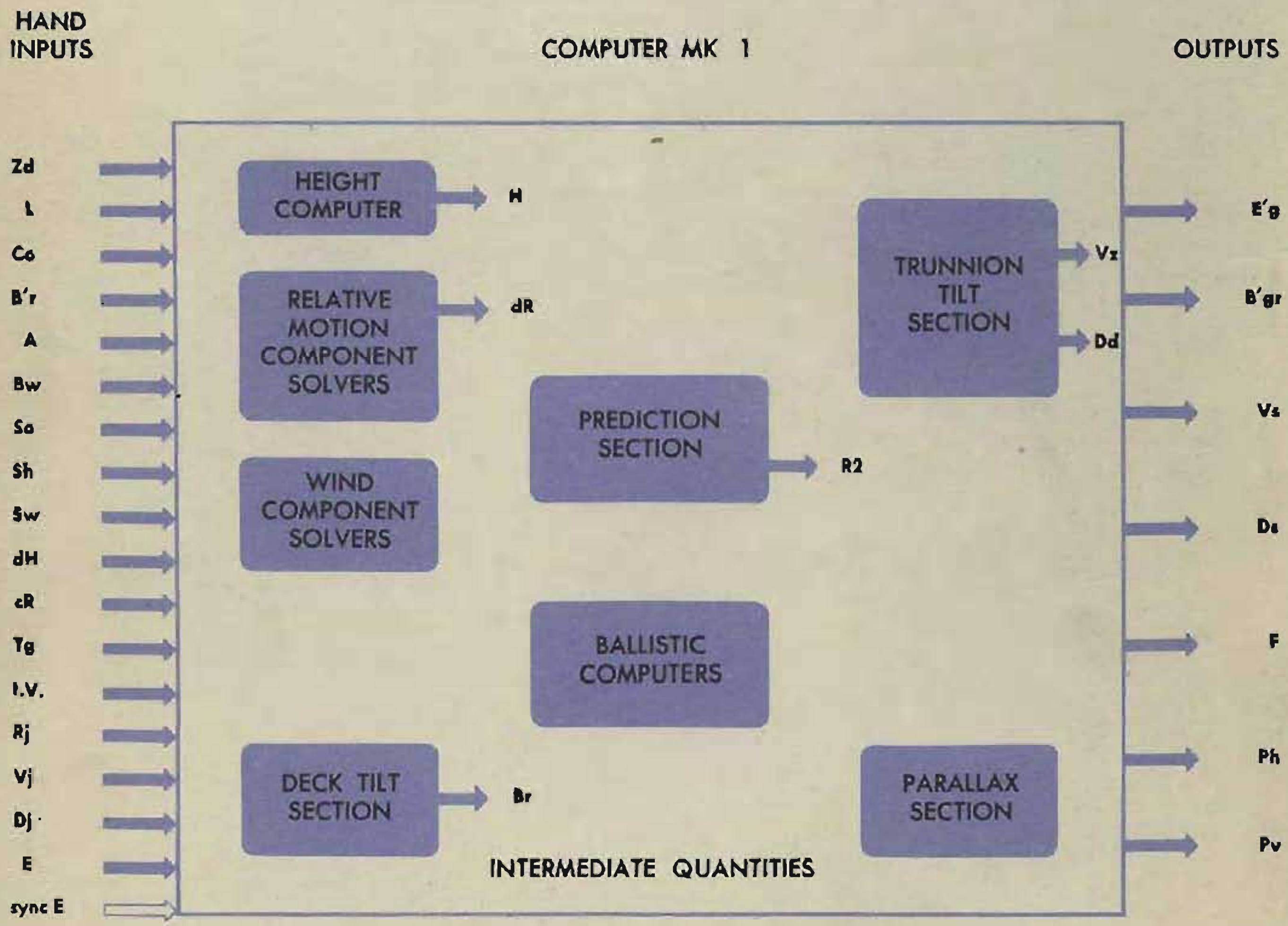
A TESTS

Including Star Shell A Tests



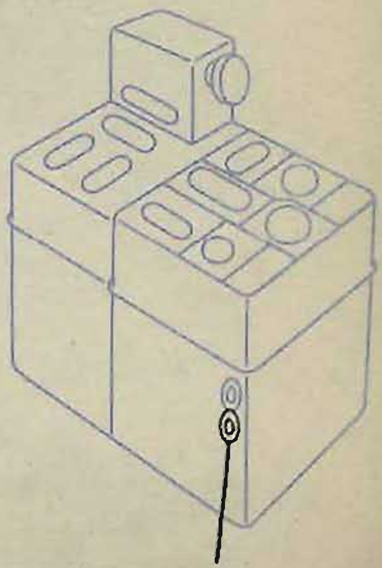
What is tested

The A tests are run to check all the computing mechanisms except those that require a time input. They are *static* tests. They check the adjustment of the dials and counters to the shaft lines and the adjustment of the shaft lines and the mechanisms to each other, as determined by various clamps. During A tests the power switch is ON, and most of the electrical circuits, servo motors, and follow-ups are operating. The time motor is OFF throughout the A tests.



When A tests are run

A tests are conducted according to the schedule specified in NAVORD FORM 1229. A complete set of A tests should also be run after any readjustment or repair.



How the computer is tested

The fifteen A test problems check the computer outputs. If the errors in the outputs are within the allowable limits of error, the test is complete.

First, the power switch is turned ON. Then specified initial input values are set into the computer. The resulting computer outputs, or transmitted quantities, are observed and compared with specified values calculated for the instrument.

If the differences between the observed and the calculated values are within the specified allowable limits, the sections of the computer checked by the A tests are in correct adjustment. When the differences are NOT within the allowable limits, reference should be made to *A Test Analysis*, page 90.

All specified inputs, calculated output values, and allowable error limits, used in running the A tests are given on the A test forms in NAVORD FORM 1229.

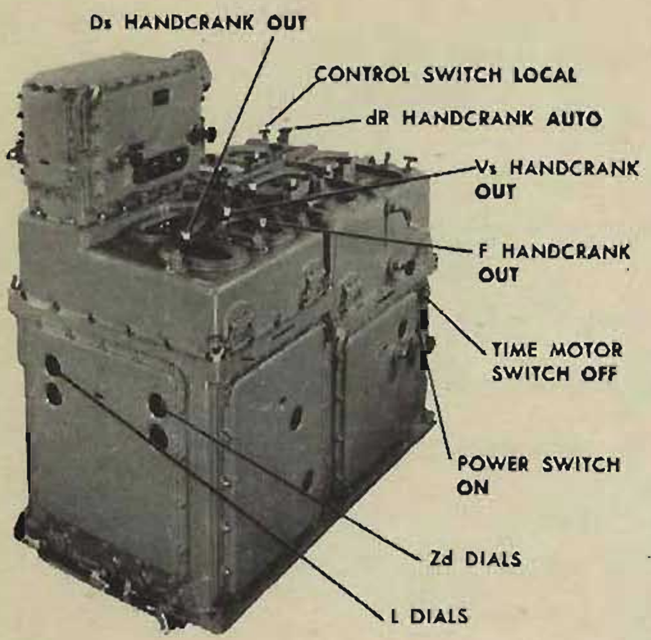
There are three test forms:

A table of input quantities for problem setup.

A record form of intermediate quantities.

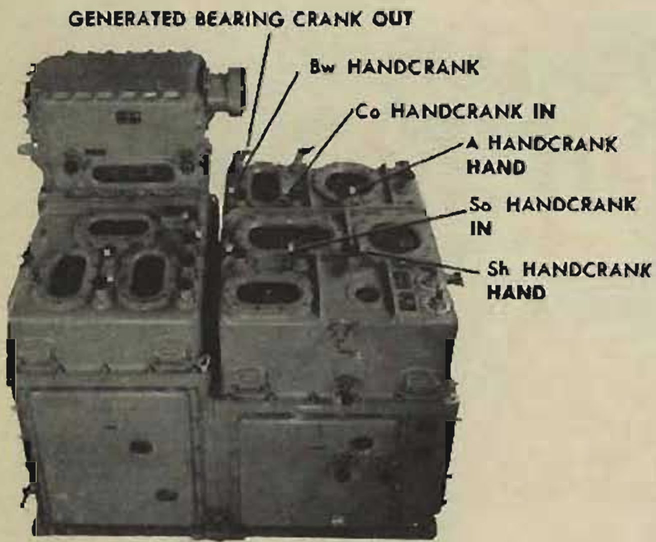
A record form of A test problem results.

SETUP without the director



Preliminary steps

1 At the fire control switchboard, energize the power circuit to the computer. All other circuits to the computer should be turned OFF.
2 At the computer, turn the power switch ON.
3 Set the *dR* handcrank in AUTO.
4 Set the *Ds*, *Vs*, and *F* handcranks in the OUT position.
5 Turn the control switch to LOCAL.
6 Keep the time motor switch OFF throughout the A tests.



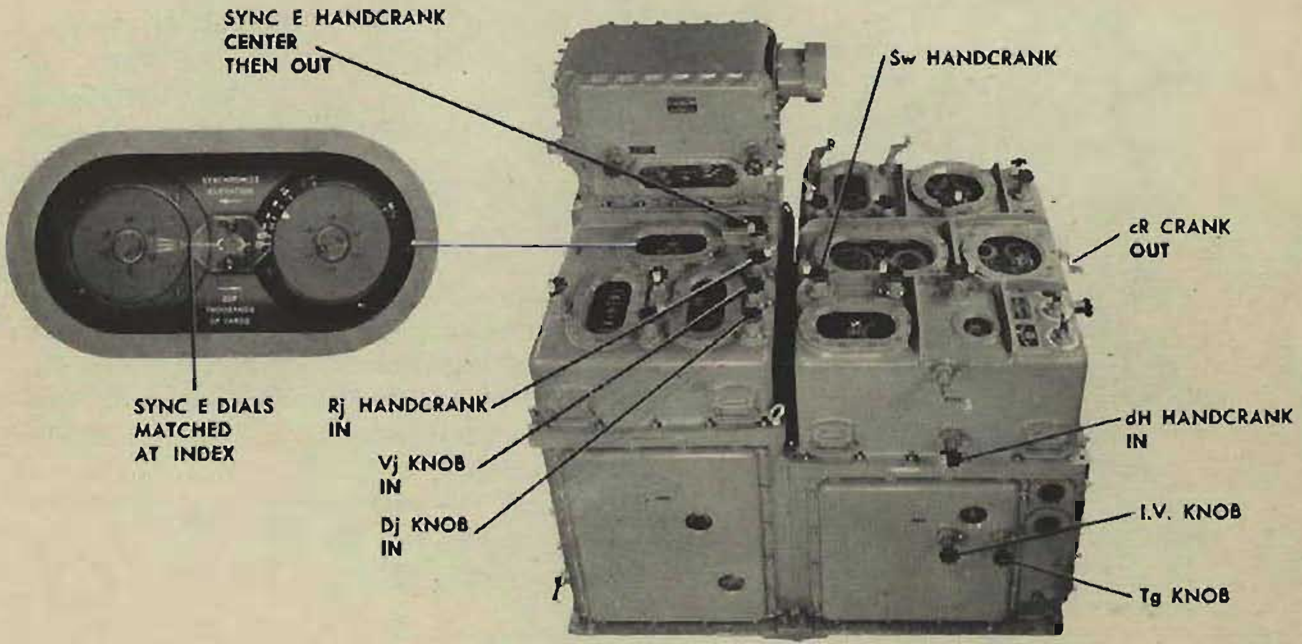
Setting up problem 1

1 Set cross-level, *Zd*, to read 1100′ on the computer dials.
2 Set level, *L*, to read 2300′ on the computer dials.
3 Set ship course, *Co*, at 180°. Use the ship course handcrank in the IN position.
4 Set director train, *B′r*, to read 0° on the stable element dials. Use the generated bearing crank in the OUT position.
5 Set target angle, *A*, at 0°. Use the target angle handcrank in the HAND position.
6 Set wind direction, *Bw*, at 0°. Use the wind direction handcrank.
7 Set ship speed, *So*, at 38 knots. Use the ship speed handcrank in the IN position.
NOTE:
On the ship speed dial, the same dial mark indicates both 0 knots and 45 knots. When 0 knots is being set on the dial, make sure that the actual value being set *is* 0 knots and not 45 knots.
8 Set horizontal target speed, *Sh*, at 300 knots. Use the target speed handcrank in the HAND position.

A TEST - COMPUTER MARK I MOD 13 *PROBLEM SETUP*

PROB. NUMBER	CROSS LEVEL	LEVEL	SHIP COURSE	DIRECTOR TRAIN	TARGET ANGLE	WIND DIRECTION	SHIP SPEED	TARGET SPEED	WIND SPEED	RATE OF CLIMB	GENERATED PRESENT RANGE	DEAD TIME	INITIAL VELOCITY	RANGE SPOT	ELEVATION SPOT	DEFLECTION SPOT	ANGLE OF ELEVATION	DIRECTOR ELEVATION	DIVING SPEED
	Zd	L	Co	B'r	A	Bw	So	Sh	Sw	dH	cR	Tg	I.V.	Rj	Vj	Dj	E	Eb	dR
1	1100	2300	180°	0°00'	0°	0°	38	300	10	+100	10000	4	2550	0	0	0	15°00'	3200	

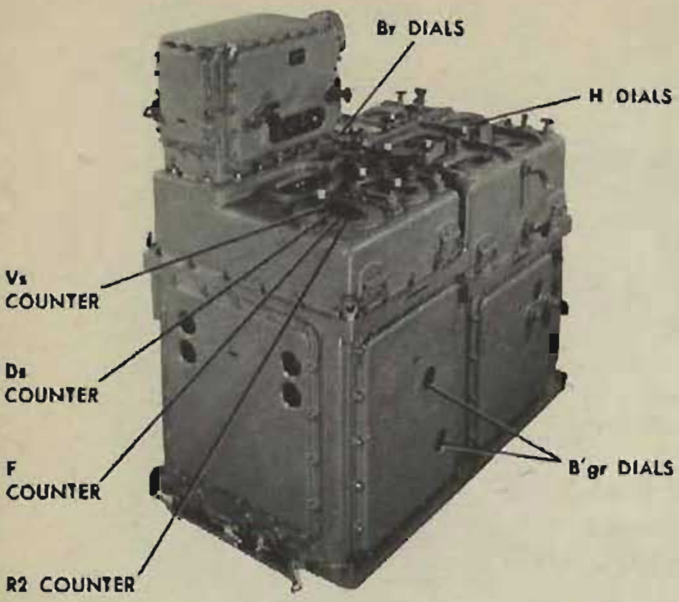
9 Set wind speed, *Sw*, at 10 knots. Use the wind speed handcrank.
10 Set rate of climb, *dH*, at +100 knots. Use the rate of climb handcrank in the IN position.
11 Set generated present range, *cR*, at 10,000 yards. Use the generated range crank in the OUT position.
12 Set dead time, *Tg*, at 4 seconds.
13 Set initial velocity, *I.V.*, at 2550 f.s.
14 Set range spot, *Rj*, on 0. Use the range spot handcrank in the IN position.
15 Set elevation spot, *Vj*, on 0. Use the elevation spot knob in the IN position.
16 Set deflection spot, *Dj*, on 0. Use the deflection spot knob in the IN position.
17 Director sight elevation, *Eb*, is not set directly, since the director is not being used. Instead, set elevation, *E*, at 15°00′, using the sync *E* handcrank in the CENTER position. Then pull the sync *E* handcrank OUT and match the sync *E* dials at the index.



The computer is now set up for A test problem 1. Read and record the problem results. Then set up and record the other test problems.

In problem 7 there is an additional input, diving speed. Set 400 DIVE on the target speed diving dial, using the range rate diving speed handcrank in HAND position.

IF THE DIRECTOR IS USED in running A tests, turn the control switch to SEMI-AUTO and set in director train, *B′r*, and director elevation, *Eb*, from the director. Match the sync *E* dials at the index with the sync *E* handcrank IN.

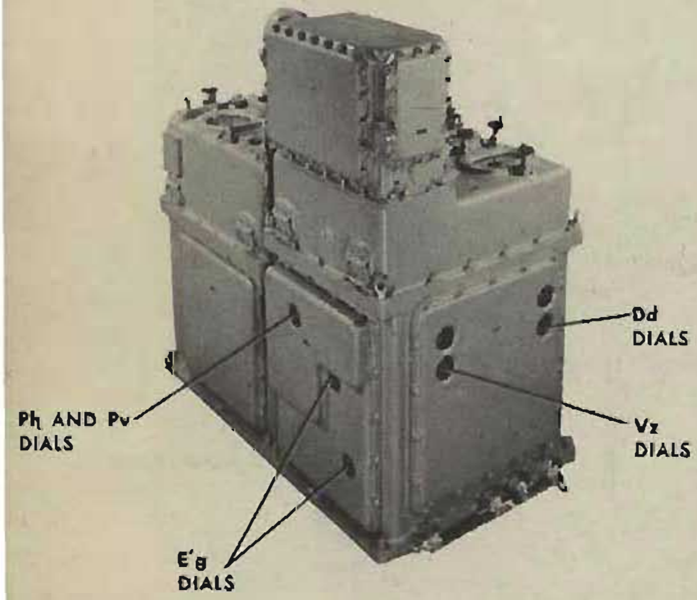


RECORDING THE A TEST PROBLEM RESULTS

Record the values on the computer dials and counters for the quantities listed below. These quantities are the transmitted quantities and those intermediate quantities which can be read without removing any covers.

The quantities to be recorded are:

1 Fuse, *F*
2 Sight angle, *Vs*
3 Sight deflection, *Ds*
4 Advance range, *R2*
5 Gun train order, *B'gr*
6 Deck deflection, *Dd*
7 Trunnion tilt elevation correction, *Vz*
8 Gun elevation order, *E'g*
9 Train parallax, *Ph*
10 Elevation parallax, *Pv*
11 Horizontal relative target bearing, *Br*
12 Height, *H*



Computing errors

As in all other computer tests, the errors in A tests are computed by algebraically subtracting the calculated value from the observed reading. For example, the error in problem 1 for gun train order, *B'gr*, would be computed as follows: The calculated value is given as 348°19'. Suppose that the instrument dial reading recorded is 348°22'. Error = (observed reading) − (calculated value) = (348°22') − (+348°19') = +3'.

PROBLEM RESULTS A TEST

PROBLEM	DATE	F *				Vs *			Ds *			R2 ‡		B'gr *		
		(A) CALC.	(B) CALC.	READ	ERROR	CALC.	READ	ERROR	CALC.	READ	ERROR	CALC.	READ	CALC.	READ	ERROR
1		13.09	13.77			3052			496.6			7724		348° 19'		

In the same problem the calculated value of *Ph* is $-0°11'$. If the instrument reading is $-0°7'$, the error will be $(-0°7') - (-0°11') = +4'$.

If the instrument reading is $-0°15'$, the error will be $(-0°15') - (-0°11') = -4'$. The sign of the error is of special importance in test analysis.

The other errors are calculated and recorded in the same way. When computing errors be careful to:

1. Use the values in column (A) for instruments with Ser. Nos. 780 and lower, and in column (B) for Ser. Nos. 781 and higher.
2. Use the values in column (C) and (E) for instruments in which director train, *B'r*, drives the parallax component solver (BB's, CB's, CA's, and CL's). Use column (D) and (F) when gun train order, *B'gr*, drives the parallax component solver (CV's, DD's, AO's, AV's, etc.).

Allowable limits of error

The allowable limits of error are based on the AVERAGE and MAXIMUM errors.

To find the average error, first add the errors (without regard to plus and minus signs) of all problems for each quantity to get the SUM of error for each quantity. Then divide the SUM by 15 (the number of errors recorded) to get the AVERAGE error for each quantity.

To find the maximum error, select the largest of all errors recorded for the quantity tested. Record it as the MAXIMUM error.

Compare the average and maximum error of each quantity with the allowable average and allowable maximum given. If the errors do not exceed the allowable limits, the A tests are completed. If the errors exceed the allowable limits, refer to the A test analysis, page 90, to locate the source of the errors.

A TEST — PROBLEM RESULTS

Dd ‡		Vz ‡		E'g *			Ph *				Pv *				Br ‡			H ‡	
CALC.	READ	CALC.	READ	CALC.	READ	ERROR	(C) CALC.	(D) CALC.	READ	ERROR	(E) CALC.	(F) CALC.	READ	ERROR	CALC.	READ	ERROR	CALC.	READ
-11° 41'		82		4170			0° 00'	-0° 11'			0° 23'	0° 23'			0° 00'			7765	

*TRANSMITTED QUANTITY ‡INTERMEDIATE QUANTITY

STAR SHELL A TESTS

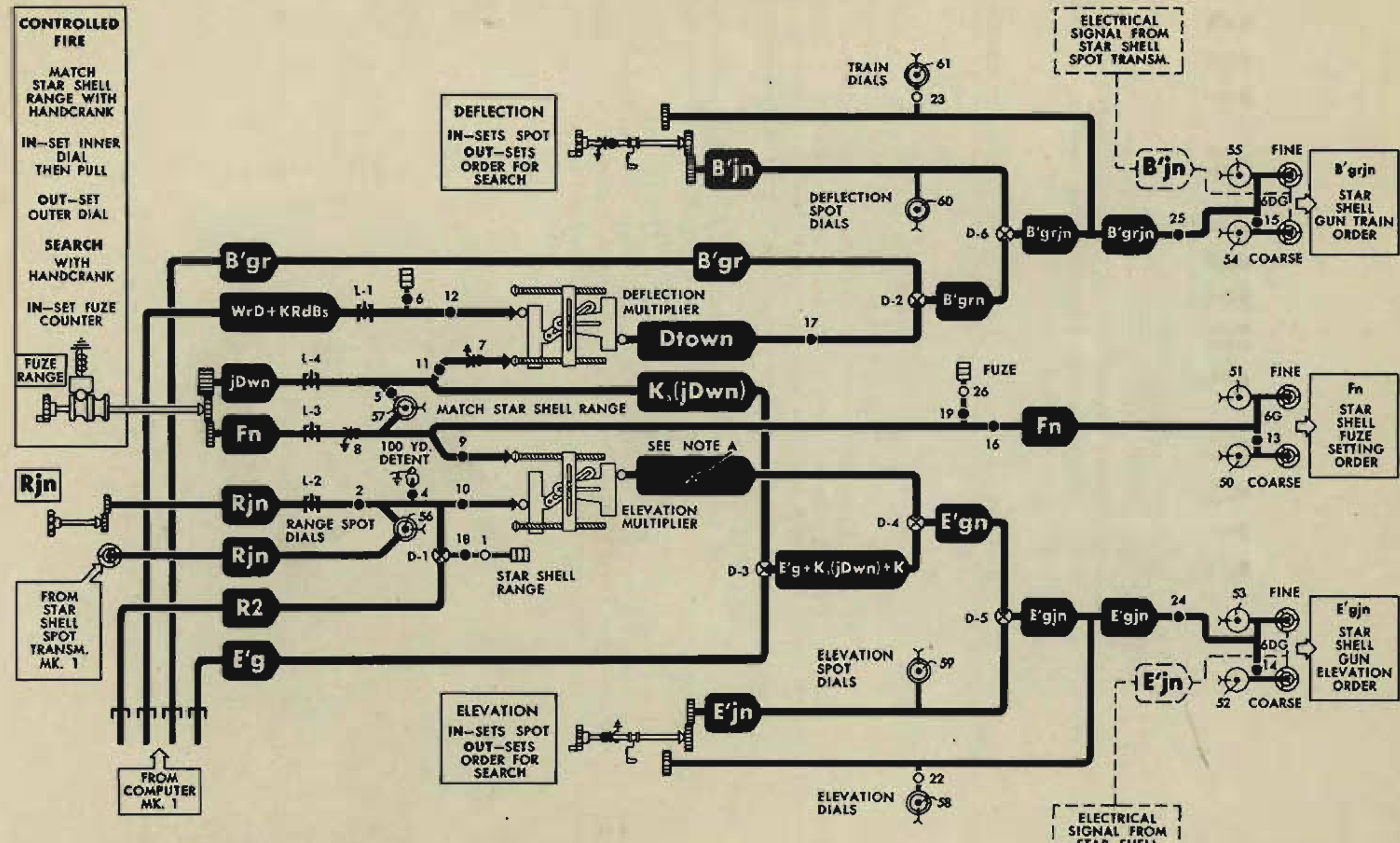
The star shell A tests check the star shell computer and those sections of the Computer Mark 1 which compute the values mechanically transmitted to the star shell computer. The star shell A tests are made in the same way as the Computer Mark 1 A tests.

The star shell computed outputs are read on the star shell gun order dials.

On the Star Shell Computer Mark 1, Mod 0, the gun order dials are under the front cover. This cover must be removed before the gun orders can be read. Star shell computer A tests may also be run without removing the front cover by using a method in which star shell gun orders are transmitted to the gun mounts and read at the mounts. This method requires that elevation and deflection spots be set at zero at the star shell spot transmitter. The errors read at the gun mounts are system errors which cannot be charged entirely to the star shell computer.

On the Star Shell Computer Mark 1, Mods 1 and 2, gun orders can be read without removing the front cover.

THE STAR SHELL COMPUTER MARK 1, MODS 1 AND 2



NOTE A— $K_1 (K_2 + Rjn)$ Fn ON MOD 1
$K_1 (K_2 + Rjn) (Fn + K_4)$ ON MOD 2

Gene Slover's US Navy Pages | Table of Contents

Star shell A test record forms

The information needed to run and record the five star shell A test problems is contained in the star shell A test record forms in NAVORD FORM 1229. There are two forms: table of problem setups and a record form for problem results.

The star shell A test input quantities are the same as the computer A test input quantities, with the addition of star shell range spot, *Rjn*, deflection spot, *B'jn*, and elevation spot, *E'jn*.

The problem result forms list the calculated values for the computed and intermediate quantities, and provide space for recording the readings and errors.

A TEST — STAR SHELL COMPUTER — MARK I PROBLEM SETUP

PROB. NUMBER	CROSS LEVEL	LEVEL	SHIP COURSE	DIRECTOR TRAIN	TARGET ANGLE	WIND DIRECTION	SHIP SPEED	TARGET SPEED	WIND SPEED	GENERATED PRESENT RANGE	DEAD TIME	INITIAL VELOCITY	STAR SHELL RANGE SPOT	STAR SHELL TRAIN SPOT	STAR SHELL ELEV. SPOT	ANGLE OF ELEVATION	DIR. ELEVATION
	Zd	L	Co	B'r	A	Bw	So	Sh	Sw	cR	Tg	I.V.	Rjn	Bjn	Ejn	E	Eb
1	2000	2000	0°	90°	270°	180°	0	0	0	6000	4	2550	0	0	0	-0° 12'	1988
2	2000	2300	225°	45°	45°	0°	20	25	10	7000	4	2500	0	0	0	-0° 10'	2290
3	2000	2000	0°	270°	90°	0°	25	25	30	10000	4	2550	OUT 1000	0	0	-0° 09'	1991
4	1700	2600	90°	0°	30°	270°	26	40	40	15000	5	2550	IN 500	0	0	-0° 08'	2592
5	2120	2600	270°	270°	270°	180°	30	30	0	5000	3	2550	0	0	0	-0° 13'	2587

NOTE: dH, Rj, Vj and Dj = 0 for all problems.

STAR SHELL COMPUTER MARK I A TEST PROBLEM RESULTS

PROBLEM	COMPUTED QUANTITIES									INTERMEDIATE QUANTITIES									
	Fn			B'grn			E'gn			WrD + 8/7 RdBs		R2		R2n		B'gr		E'g	
	CALC.	READ	ERROR	CALC.	READ	ERROR	CALC.	READ	ERROR	CALC.	READ	CALC.	READ	CALC.	READ	CALC.	READ	CALC.	READ
1	12.85			89°54'			2612			0		6000		7000		89°54'		2238	
2	15.49			50°33'			2982			32.22		6941		7941		46°37'		2610	
3	29.65			275°26'			3177			54.99		9995		11995		271°00'		2604	
4	38.82			359°35'			4231			23.56		13608		14108		357°58'		3773	
5	10.33			261°23'			3177			961.43		5008		6008		267°36'		2787	
	SUM																		
	AVG.	.05			8			8											
	MAX.	.15			18			18											

DATE:

TESTED BY:

Setting up star shell problem 1

1 Set up the Computer Mark 1 for A tests.

2 On Star Shell Computer Mark 1, Mod 0:

a) Remove the front cover, or if the system check is preferred, set up star shell gun order transmission to the gun mounts.

b) Set deflection and elevation spot at 0 at the star shell spot transmitter.

On Star Shell Computer Mark 1, Mods 1 and 2:

a) With the deflection and elevation handcranks in SPOT position, set deflection and elevation spots at 0.

b) Check that each coarse spot dial index is matched at the fixed index.

3 At the computer, set in the hand inputs listed in the problem setup record form for problem 1. Use the handcrank in the positions described for the Computer Mark 1 A tests.

4 At the star shell computer, set the range spot ring dial at 0.

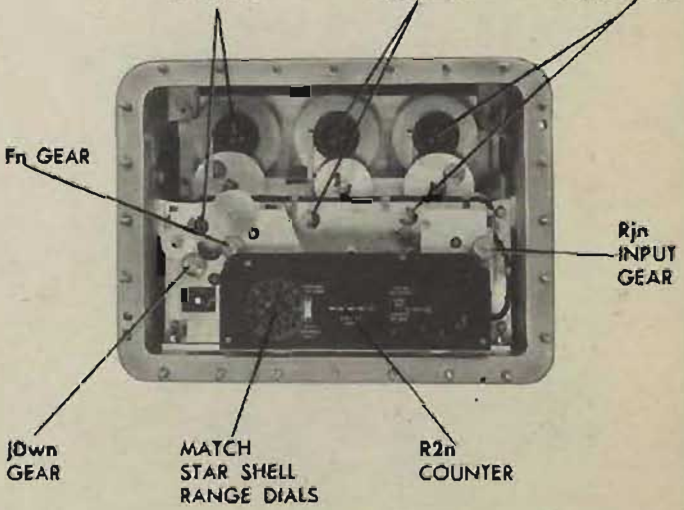
5 Set fuze range by matching the inner star shell range dial to the star shell range counter. Use either the range handcrank in the IN position or the *Fn* gear. To keep fuze errors within the allowable limits, it is important to set fuze range at its exact value.

6 Match the star shell range ring dial to the star shell range counter. Use either the range handcrank in the OUT position or the *jDwn* gear.

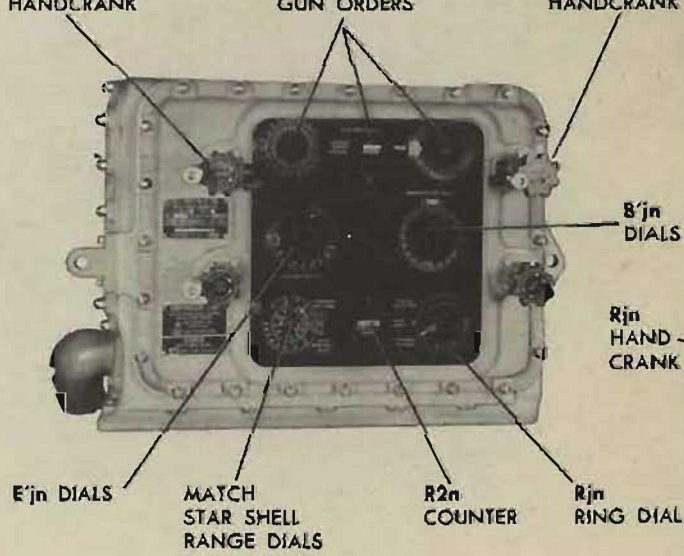
7 Read and record the star shell gun orders.

Make all other star shell A tests, following the same procedure. Calculate and record star shell A test errors. These errors are calculated by the method used to calculate Computer Mark 1 A test errors.

If the errors do not exceed the given allowable limits, the star shell A test results are satisfactory. If the errors exceed the allowable limits, refer to star shell A test analysis, page 90, and locate the source of error.



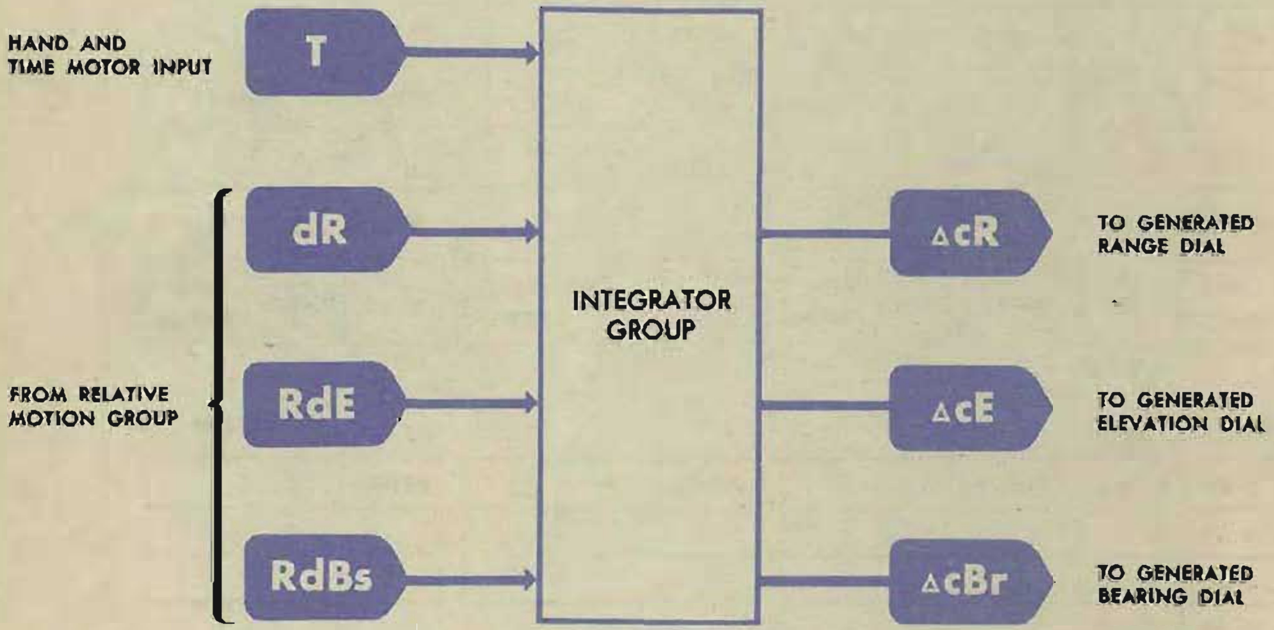
MOD 0



MODS 1 AND 2

B TESTS

B tests check both the adjustment of the integrator group and the relationship of the relative motion group to the integrators. Specified inputs of time, *T*, and of relative motion rates, *dR*, *RdE*, and *RdBs*, are supplied to the integrator group, and the integrator outputs are then recorded at specified time intervals. The integrator outputs recorded are the generated changes of range, elevation, and bearing, ΔcR, ΔcE, and ΔcBr.



How B tests are run

The B tests consist of three sets of problems: eleven problems for testing range, eleven for elevation, and eleven for bearing.

The generated values of range, elevation, and bearing are read on the computer dials at the end of each specified time interval and entered on the record forms for problem results. They are then compared with a set of calculated correct values. If the B test results are to be satisfactory, the summary average and maximum rate errors must come within the allowable limits specified on the test forms.

The schedule for running B tests is given in NAVORD Form 1229.

B TEST FORMS

All the forms required for setting up and recording results of B tests are provided in NAVORD Form 1229. Sample sheets are shown here.

B TESTS

BEARING — PROBLEM SETUP

PROB. NO.	So KNOTS	Sh KNOTS	Br DEG.	A DEG.	E DEG.	cR YARDS	dB DEG./MIN.
23	0	0	0°	0°	0°	5000	0°
24	35	360	270°	270°	60°	2150	-711.2°
25	35	360	270°	270°	0°	1700	-449.7°

B TEST — PROBLEM RESULTS

RANGE — PROBLEM 5

TIME MIN.SEC.	CALC.	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR
0:00	22000	22000	0	–	22000	0	–	22000	0	–
0:30	20311									
1:00	18622									
1:30	16933									
2:00	15244									
DATE:			SUM							

B TESTS — SUMMARY SHEET

RANGE — ALLOW OVERALL: AVG. 26, MAX. 78

PROB.	DATE	CK. BY	AVG.	MAX.
2				
3				
4				
5				
6				
7				
8				

ELEVATION — ALLOW OVERALL: AVG. 34, MAX. 102

PROB.	DATE	CK. BY	AVG.	MAX.
13				
14				
15				
16				
17				
18				
19				

BEARING — ALLOW OVERALL: AVG. 34, MAX. 102

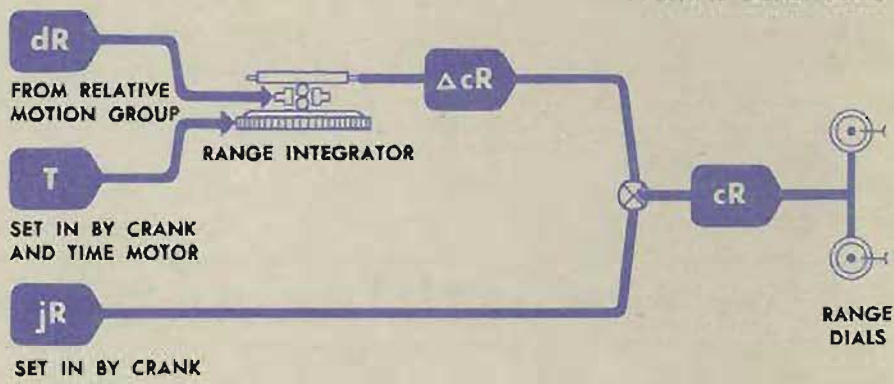
PROB.	DATE	CK. BY	AVG.	MAX.
24				
25				
26				
27				
28				
29				
30				

Range B tests check ΔcR

Generated change of range, ΔcR, is computed by multiplying direct range rate, dR, by time, T. dR, from the relative motion group, positions the range integrator carriage. A specified value of time, T, set in by the time crank and time motor, drives the range integrator disk. The integrator output is ΔcR. ΔcR is added to a value of jR set in by the generated range crank. jR plus ΔcR gives generated range, cR.

The value of cR is read on the generated range dials at the time intervals specified on the record form for problem results. The dial readings are recorded on this form and compared with the calculated values.

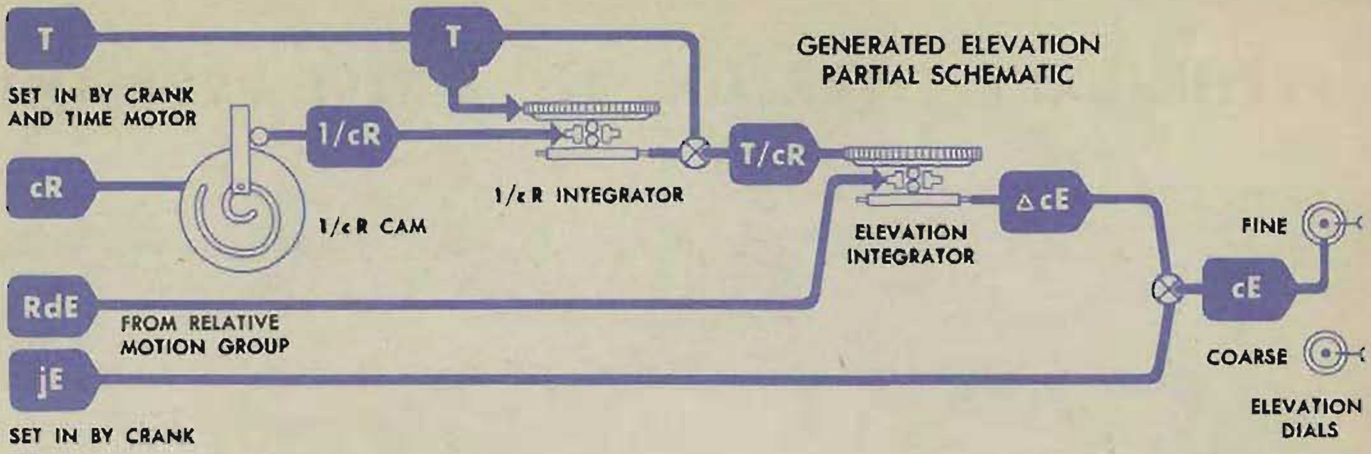
GENERATED RANGE
PARTIAL SCHEMATIC



Elevation B tests check ΔcE

Generated change of elevation, ΔcE, is computed by multiplying linear elevation rate, RdE, by T/cR. Generated range, cR, is the input to the $1/cR$ cam. The cam output, $1/cR$, positions the $1/cR$ integrator carriage. The input to the $1/cR$ integrator disk is a specified value of time which is set in by the time crank and time motor. The output of the $1/cR$ integrator is T/cR, which becomes an input to the disk of the elevation integrator. The input to the elevation integrator carriage is RdE, an output of the relative motion group. The output of the elevation integrator is ΔcE. This is added to a value of jE set in by the generated elevation crank. jE plus ΔcE is generated elevation, cE.

The value of cE is read on the fine generated elevation dial at the time intervals specified on the record form for problem results. The dial readings are recorded on this form and compared with the calculated values.



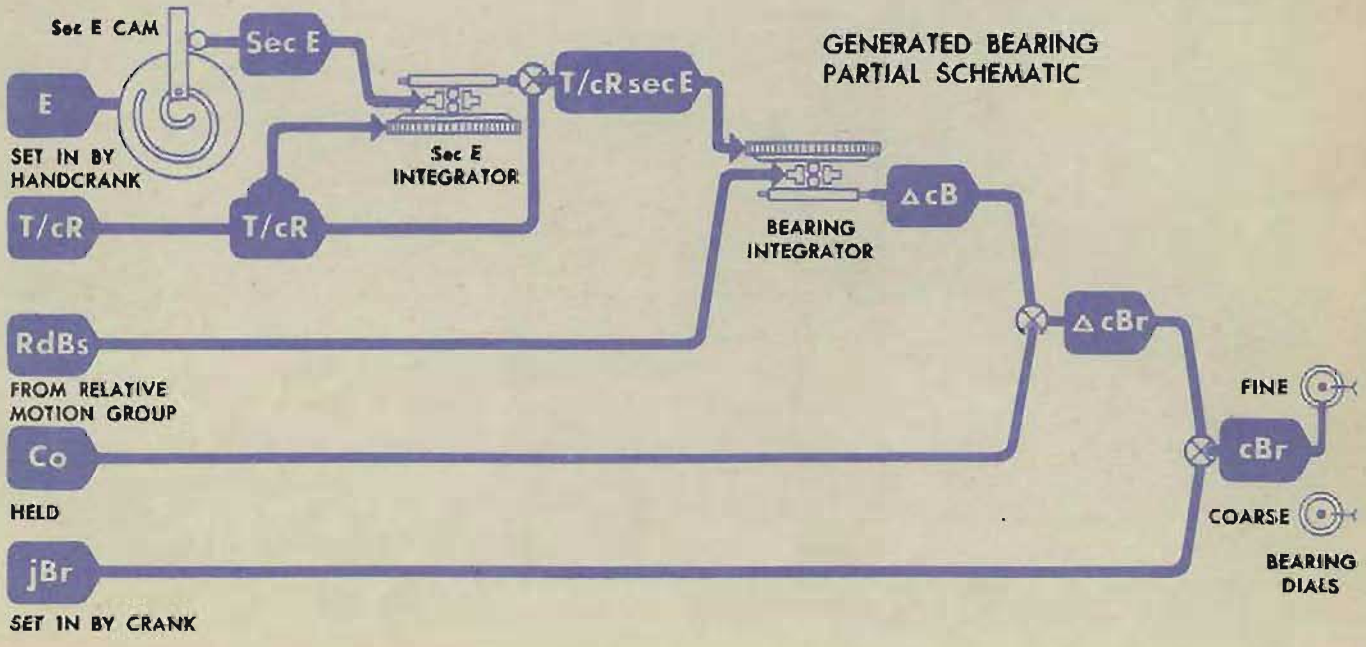
Bearing B tests check ΔcBr

Generated change of bearing, Δ*cBr*, is computed by multiplying the linear deflection rate, *RdBs*, by *(T/cR)* sec *E*. Target elevation, *E*, the input to the sec *E* cam, is set in by the sync *E* handcrank. The cam output, sec *E*, is the input to the sec *E* integrator carriage. The input to the sec *E* integrator disk is *T/cR*.

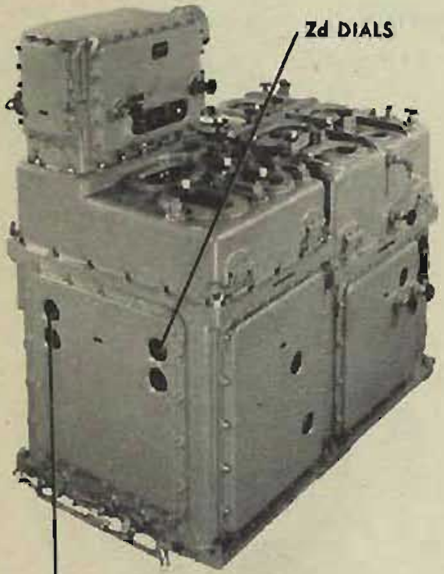
The output of the sec *E* integrator is *(T/cR)* sec *E*. This quantity becomes an input to the bearing integrator. The other input to the bearing integrator is *RdBs*, from the relative motion group. The output of the bearing integrator is Δ*cB*.

Δ*cB* combines with *Co*, which is held at a constant value to form Δ*cBr*. Δ*cBr* is added to a value of *jBr*, set in by the generated bearing crank, to form generated relative target bearing, *cBr*.

The value of *cBr* is read on the fine generated bearing dial at the time intervals specified on the record form for problem results. The dial readings are recorded on this form and compared with the calculated values.



PRELIMINARY SETUP FOR ALL B TEST PROBLEMS



1 At the fire control switchboard, make sure that all the switches connecting the computer to the director are OFF

2 At the stable element, set level, *L*, to read 2000′ on the computer level dial.

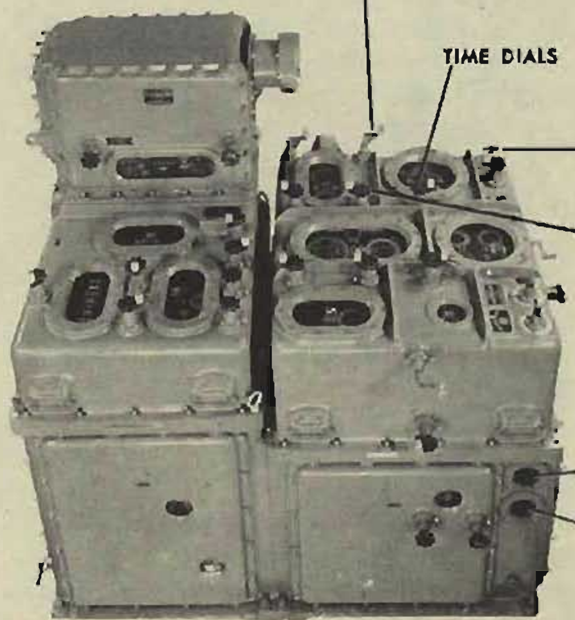
3 At the selector drive, set cross-level, *Zd*, to read 2000′ on the computer cross-level dial.

4 At the computer, turn the power switch ON.

5 Turn the control switch to SEMI-AUTO.

6 Lock the ship course handcrank in its IN position.

7 Pull the time crank OUT, and turn it clockwise to set the graduation mark on the half-second dial at the fixed index. Then, with the time crank IN, zero the minute and second dials. All the time dials should be exactly at zero at the start of each B test problem.



TIME DURING B TESTS

In B tests, actual time is not used. Time is represented by revolutions of the time shaft line as recorded on the time dials. The actual time required for the time shaft to turn the time dials to the value of two minutes, for example, might be more than two minutes during a test, but this would not affect the test.

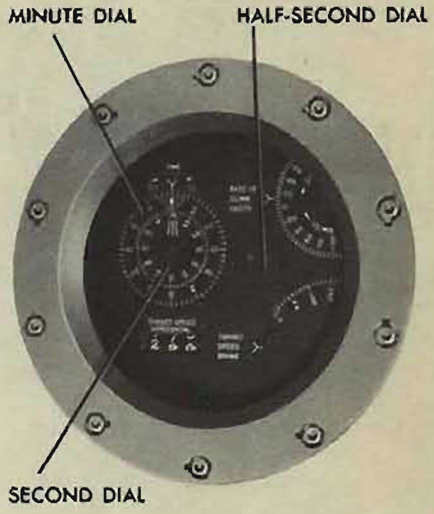
For this reason, the time motor regulator, which controls the speed of the time motor, is not tested by the B tests but is tested separately as described on page 84.

At the beginning of a problem

Each B test problem begins at the moment that the time dials are moved off zero. If, however, the time motor were turned ON at the beginning of the problem, the suddenly applied load might cause slippage in the integrators and introduce an error into their outputs. To avoid this, each problem is started by turning the time crank in its OUT position to work the time shaft line up to speed. Three or four revolutions of the time handcrank are usually sufficient, but practice is needed before it can be done smoothly.

When the shaft line has been brought up to speed, the time motor is turned ON, and the time handcrank is lowered to its CENTER position.

In the bearing problems it is especially important that the time shaft line be brought up to speed gradually; the inertia of the bearing filter may otherwise cause excessive slippage in the bearing integrator.



TIME DIALS

At the end of a problem

To avoid running a problem beyond the specified time, the time motor is always turned OFF several seconds *before* the time dials reach the specified time limit for the test. The time crank in its OUT position is used to turn the time shaft line slowly until the time dials register the exact reading required. The half-second dial should be used to obtain the exact dial reading.

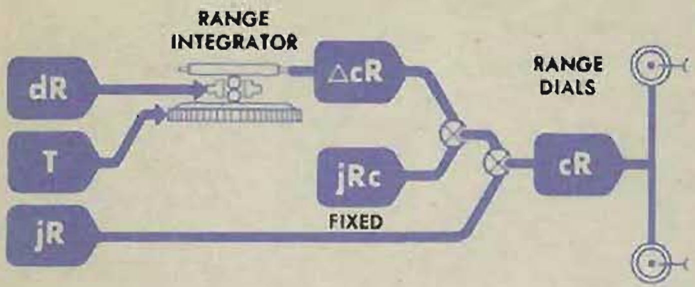
When the time motor is switched OFF, it is desirable to turn the time crank up to the correct speed in the CENTER position and then bring it OUT into mesh with the time line without jarring the line.

With practice this can be done quite smoothly. The time crank can then be used to aid or retard the line so that the time dials will stop right on the desired value, without overtravel.

WARNING

If the time dials are accidentally turned beyond the specified final time reading, they must *not* be turned back because this may damage the time motor regulator. The time dials must be zeroed and the problem started all over again.

RANGE B TESTS



For each range B test problem, the inputs specified on the range B test problem setup form are set into the computer to establish a fixed value of direct range rate, *dR*. The range rate diving speed handcrank is switched to AUTO.

For each problem, the time dials are set at zero, and generated range is then set at the initial value specified on the record form for problem results.

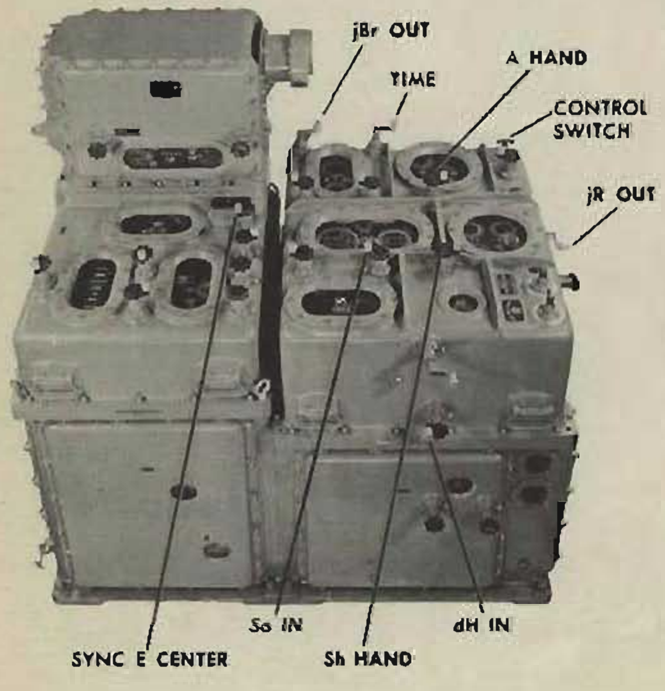
The output of the range integrator, ΔcR, is tested by reading the generated range dials at given time intervals and comparing these readings with the calculated values.

Setting up the computer for range problem 2

B TEST

RANGE PROBLEM SETUP

PROB NO.	So KNOTS	Sh KNOTS	dH KNOTS	Br DEG.	A DEG.	E DEG.	cR YARDS TO START	dR YDS. MIN.
1	0	0	0	90°	90°	0°	5000	0
2	35	395	0	0°	0°	0°	22000	-14525.4
3	0	300	0	90°	0°	0°	22000	-10134.0
[illegible]	0	0	235	90°	90°	60°	[illegible]	[illegible]



1. Turn the ship speed handcrank in the IN position to set *So* at 35 knots.
2. Shift the target speed handcrank to HAND, and set *Sh* at 395 knots.
3. Push the rate of climb handcrank IN, and set *dH* at 0 knots.
4. Set *Br* at 0 degrees. To do this, turn the control switch to LOCAL and use the generated bearing crank in the OUT position. Return the control switch to SEMI-AUTO.
   Note that *Br* can also be set into the computer by transmitting *B'r* from the director. (Since *L* and *Zd* are both set at 2000', $B'r = Br$).
5. Turn the target angle handcrank to HAND and set *A* at 0 degrees.
6. Put the sync *E* handcrank in its CENTER position, and set *E* at 0 degrees.

7 Check that all the time dials are on zero, and that the graduation on the half-second dial is at the fixed index.

8 Pull the generated range crank OUT, and set *cR* at 22,000 yards. This initial value of *cR* for problem 2 is given on the record form for problem results, opposite the 0:00 minutes time dial reading.

Running range problem 2

1 Turn the time crank in the OUT position to work up the speed of the time shaft line.

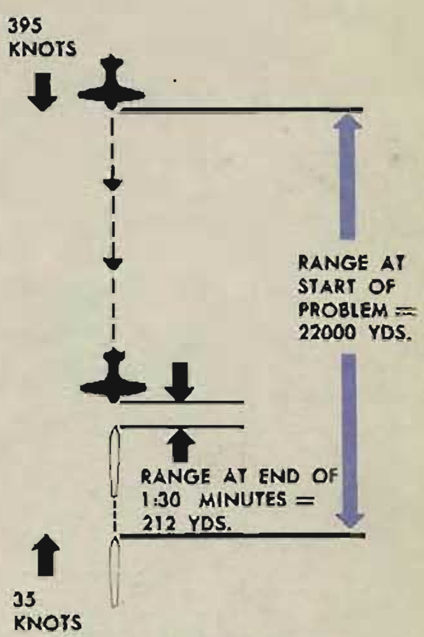
2 As soon as the time shaft line is turning at approximately operating speed, turn the time motor switch ON and let the crank disengage.

3 Run the problem for about 25 seconds on the time dials, and then turn the time motor switch OFF.

4 Turn the handcrank slowly to bring the second dial almost to 30. Then, very slowly, make the half-second dial index line up with the fixed index. This should bring the second dial to read 30 against the fixed index.

5 Read the *cR* dial and enter the *cR* reading on the record form for problem results.

6 Run the problem in the same manner for the remaining time intervals. If the time crank is turned beyond the specified time dial reading, the time dials must be reset on zero and the problem repeated.



PROBLEM 2
SHOWS cR DECREASING
AT 430 KNOTS

B TEST — *PROBLEM RESULTS*

RANGE — *PROBLEM 2*

TIME MIN.SEC	CALC.	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR
0:00	22000	22000	0	—	22000	0	—	22000	0	—
0:30	14737	14740	+3	6						
1:00	7475	7480	+5	5						
1:30	212	220	+8	5						
DATE:			SUM	16						
			AVG	5						
TESTED BY:			MAX	6						

Recording the problem results

Record the *cR* dial readings under problem results in the column headed: READ.

The remaining range problems, with the exception of problem 1, are set up, run, and recorded in exactly the same manner as range problem 2. Problem 1 is the zero rate problem and is run for a single time interval of 3 minutes. A separate allowable maximum for this problem is specified on the zero rate summary sheet.

COMPUTING ERRORS IN RANGE B TESTS

The problems selected for the B tests are extreme cases in which the errors in the mechanisms are magnified and easily noticed. The group of mechanisms used to generate changes of range is operating properly if the B test errors are within the allowable limits specified on the B test summary sheets.

First the linear range errors are found by comparing the recorded readings of *cR* with the mathematically calculated *cR*. When the linear errors have been recorded, the problem rate errors, the summary average rate errors, and the summary maximum rate errors are calculated.

The allowable limits are based on the average rate error for all the range problems, called the summary average, and the maximum rate error for all the range problems, called the summary maximum.

B TEST PROBLEM RESULTS

TIME MIN.SEC	CALC.	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR
RANGE								PROBLEM 3		
0:00	22000	22000	0	—	22000	0	—	22000	0	—
0:30	16933	16920	-13	26						
1:00	11866	11840	-26	26						
1:30	6799	6755	-44	29						
2:00	1732	1670	-62	31						
DATE:			SUM	112						
			AVG	28						
TESTED BY:			MAX	31						

Linear errors

The linear error is the observed reading minus the calculated value. Linear errors may be either plus or minus.

Suppose that in problem 3 the values of generated range read on the dials during the test were 16,920 yards after 30 seconds, 11,840 yards after one minute, and so on, as recorded in the READ column. At the first reading, the linear error is 16,920–16,933, which is –13. At the second reading, *cR* is 11,840. The linear error for the second reading is 11,840–11,866, which is –26. In the same way the linear errors for the third and fourth readings are –44 and –62.

Problem rate errors

The rate error is the linear error at each reading divided by the elapsed time in minutes between the start of the problem and the time of reading.

$$\text{Rate error} = \frac{\text{linear error}}{\text{time in minutes}}$$

In problem 3, the linear error at the second reading is −26. (Minus and plus signs can be ignored in calculating rate errors.) The time is 1 minute.

$$\frac{26 \text{ yards}}{1 \text{ minute}} = 26 \text{ yards per minute}$$

The rate error for this reading is therefore 26.

Problem average and problem maximum rate errors

To find the problem average rate error, add all the rate errors and divide their sum by the number of readings. In problem 3, the problem average rate error is 112/4, which is 28.

The problem maximum rate error is the largest rate error. In this problem, the problem maximum rate error is 31.

The linear errors, rate errors, average rate error, maximum rate error for each range problem are recorded on the form for problem results. All the problem averages and maximum rate errors are then recorded in the columns provided on the B test summary sheets.

SUMMARY SHEET

RANGE				
ALLOW OVERALL			AVG. 26	MAX. 78
PROB.	DATE	CK. BY	AVG.	MAX.
2			5	6
3			28	31
4			67	72
5			20	23
6			8	11
7			19	22
8			6	10
9			24	30
10			23	29
11			15	18
OVERALL AVG. & MAX.			21.5	72

Summary average rate errors

The problem averages are added and their sum is entered in the space provided on the summary sheet. In this set of problems the sum is 215. The summary average is then found by dividing the sum of the problem averages by the number of problem averages recorded. The summary average in this case is 215/10, which is 21.5. This summary average is then compared with the given allowable average. It must not exceed the allowable average, which in this case is 26.

Problem maximum rate errors

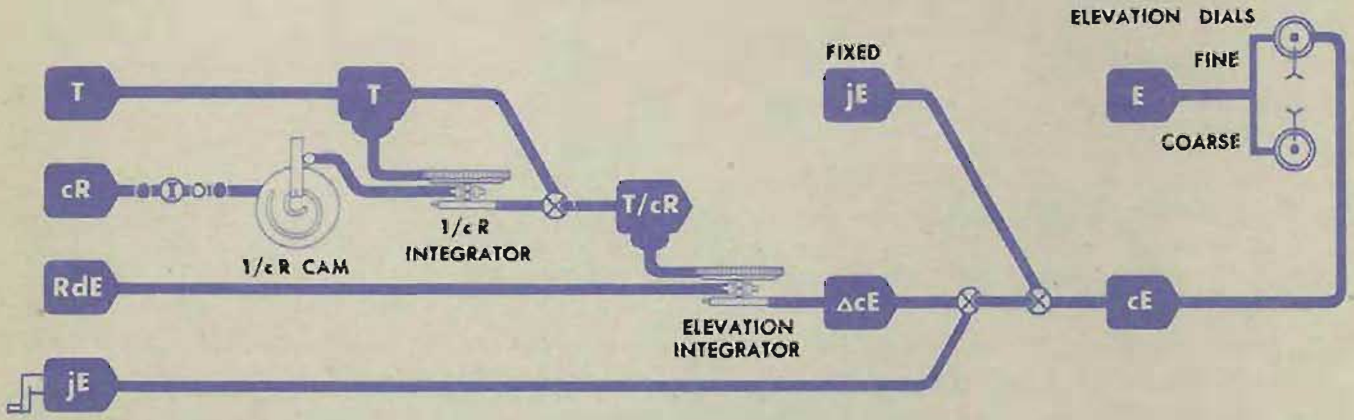
The largest problem maximum rate error is entered as the summary maximum and is compared with the given allowable maximum. In this example, the largest problem maximum is 72. The allowable maximum is 78. Since in this example both the summary average and the summary maximum are within the allowable limits, these results demonstrate that the range integrator output, ΔcR, is sufficiently accurate.

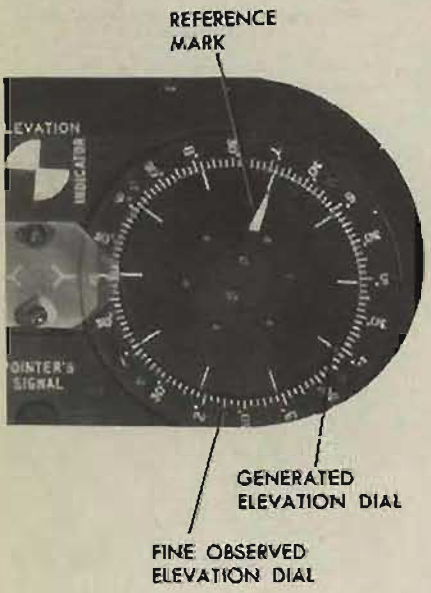
ELEVATION B TESTS

For each elevation B test problem, the initial inputs specified on the elevation B test problem setup form are set into the computer to establish a fixed value of linear elevation rate, *RdE*.

For each problem, the time dials are set at zero, and generated elevation is then set at the initial value specified on the record form for problem results.

The output of the elevation integrator, ΔcE, is tested by reading the generated elevation dial at given time intervals and comparing these readings with the calculated values.





Marking the cE dial

The output of the elevation integrator is read on the generated elevation dial against the fine observed elevation dial. Each dial has a value of 10° per revolution.

For convenience in this discussion, *jE* is the elevation value introduced by turning the generated elevation crank, and *cE* is the elevation value generated by the elevation integrator in the time interval specified by the test problem.

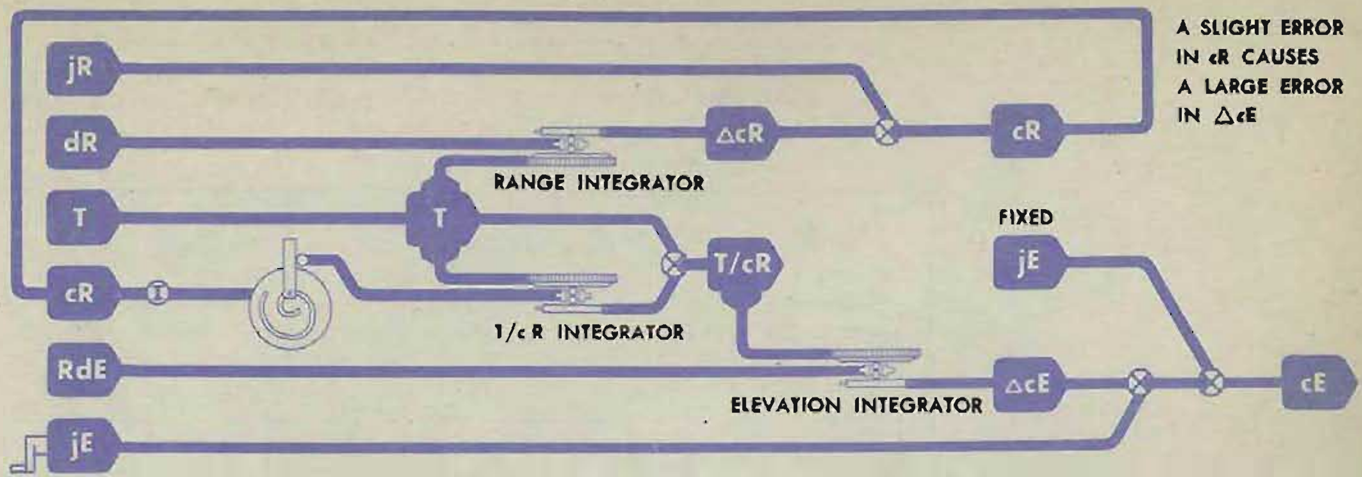
One of the indexes on the generated elevation dial must be selected as a reference. This is done by selecting the index in line with one of the dial hub screws, or by identifying an index mark with a pencil line, a spot of paint, or a small triangle of adhesive tape.

With the dial marked, *jE* can be introduced with the generated elevation crank OUT. The value of *cE* can then be read against the fine observed elevation dial at the end of the specified time interval.

On earlier machines there are fine and coarse generated elevation dials. Each dial has a special-shape index mark for use as a reference.

Preventing changes in range

Generated range, *cR*, is one of the fixed inputs in elevation and bearing B tests. The slightest change in *cR* during elevation and bearing B tests can cause excessive errors in generated elevation, *cE*, and generated bearing, *cBr*. To prevent any change in *cR* during the tests, a zero range rate is established.

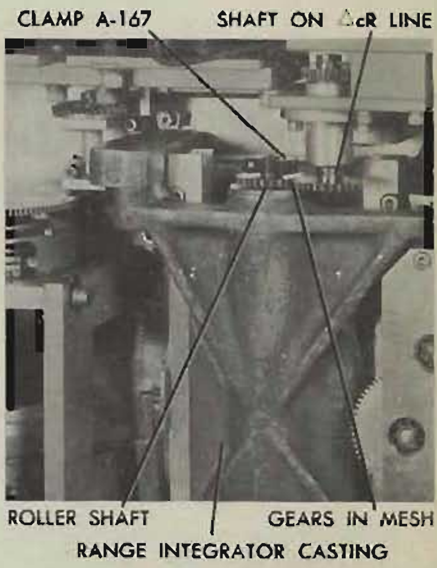


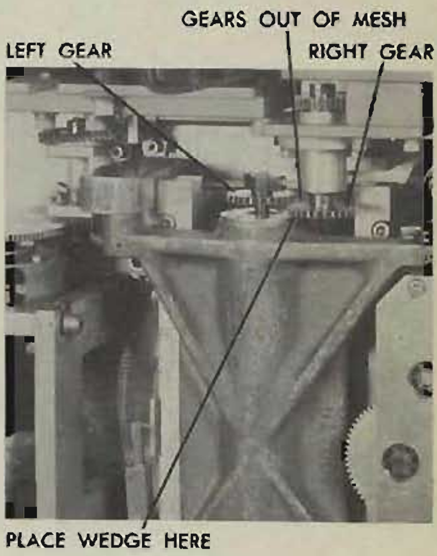
A SLIGHT ERROR IN cR CAUSES A LARGE ERROR IN ΔcE

To establish a zero range rate, set the *dR* dial at zero, turn the time motor ON, and watch the ΔcR gearing through the access hole to the left of the range rate ratio knob. Adjust the *dR* handcrank until the ΔcR gearing stands still.

In older machines no access hole was provided. On these machines set *dR* as follows: Set the *dR* dial at zero with the *dR* handcrank at HAND; then set *cR* at some known input value with the generated range crank. Run the time motor for 3 minutes and observe whether there is any change in *cR*. If the *cR* dial reading changes, adjust the *dR* handcrank until the *cR* reading remains constant.

In later computers the range integrator may be disconnected from the ΔcR line to eliminate wear on the integrator disk at the zero position. When the range integrator is disconnected, errors in generated range are eliminated. Initial range, *jR*, can be set at the given value at the beginning of an elevation problem, and the value of range *will not change* during the problem. The *dR* handcrank should be set at AUTO when the range integrator is disconnected.



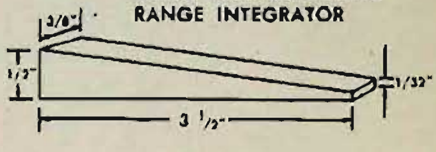


Disconnecting the range integrator

1. Remove the plug from the range integrator access hole in cover 1. This brings two spur gears into view. The left gear is on the roller shaft of the range integrator, and the right gear is on a shaft which is part of the ΔcR line.
2. Turn the time crank *clockwise* in the OUT position until the screw of clamp A-167 on the left gear can be reached easily.
3. Loosen clamp A-167.
4. Carefully raise the left gear just out of mesh with the right gear.

   CAUTION:
   Do not remove the left gear from the integrator shaft.
5. With the left gear raised, slip-tighten clamp A-167. Making the clamp too tight may cause the gear hub to collapse.
6. Lock the right gear. To do this, insert a wedge under the gear *by hand*. Any pressure greater than hand pressure may injure the gear. The wedge should lie between the right gear and the integrator casting and should stick out beyond the plug hole. This wedge should be made of high-grade bakelite or some other material that will not chip or break easily and which will not damage the gear.

SIZE OF WEDGE TO BE USED WHEN DISCONNECTING RANGE INTEGRATOR



Running elevation B tests

1 First establish a zero range rate and then set the computer dials at the specified values given on the elevation B test problem setup form.

ELEVATION PROBLEM SETUP

PROB. NO.	So KNOTS	Sh KNOTS	dH KNOTS	Br DEG.	A DEG.	E DEG.	cR YARDS	dE DEG./MIN.
12	0	0	0	90°	90°	0°	5000	0
13	35	285	0	180°	180°	80°	2400	-254.1
20	30	280	+120	0°	0°	50°	4000	+152.2

2 Using problem 13, for example, zero the time dials and then match the selected index on the fine generated elevation dial with the 0°00′ graduation on the observed elevation dial, using the generated elevation crank in the OUT position.

B TEST PROBLEM RESULTS

ELEVATION PROBLEM 13

TIME MIN.SEC.	CALC.	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR	READ	ERROR	RATE ERROR
0:00	0°00′	0°00′	0	—	0°00′	0	—	0°00′	0	—
0:30	127°05′	126°56′	-7	14						
1:00	254°06′	253°50′	-16	16						
DATE:			SUM	30						
			AVG	15						
TESTED BY:			MAX	16						

3 Run the problem for 30 seconds, the first specified time interval, keeping count of the dial revolutions. Begin and finish the run, using the time crank as described for the range problems.

4 Read the generated elevation ring dial against the selected index and record the value on the record form for problem results.

5 Complete the problem in the same manner.

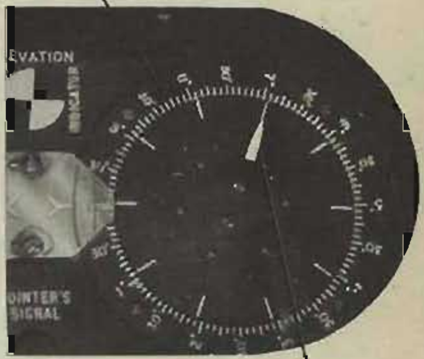
ELEVATION PROBLEM 20

0:00	0°00′	0°00′	0	—	0°00′	0	—	0°00′	0	—
0:30	283°53′	283°40′	-13	26						

Reading the generated elevation dial

The calculated values of generated elevation, given as $360° - cE$, were devised in this form to represent the direct dial readings without regard to the direction of rotation. The full value of *cE* cannot be read on the fine dial, because the value of a full revolution of the dial is only 10°. Instead, the number of revolutions of the fine dial is counted and compared with the value of *dE* in deg./min. given on the problem setup form. (*dE* represents the angular rate of the change of elevation.) If the number of revolutions of the dial checks with the *dE* value given, then *the part of the calculated value not read* on the generated dial is copied into the instrument reading column, followed by the actual fine dial reading.

For example, consider problem 13. In this problem the calculated value is 127°03′ at the end of the first 30-second time interval. The value of *dE* is given as −254.1 deg./min. For 30 seconds the value is −127.05°. Since the fine dial has a value of 10° per revolution, it should make 12 revolutions in the 30-second time period. If after making twelve full revolutions, the selected index mark on the generated elevation dial stops at the reading of 6°56′, as shown, then this reading 6°56′ is put down in the instrument reading column and the rest of the reading is copied from the calculated value, giving 126°56′ as the full entry value.



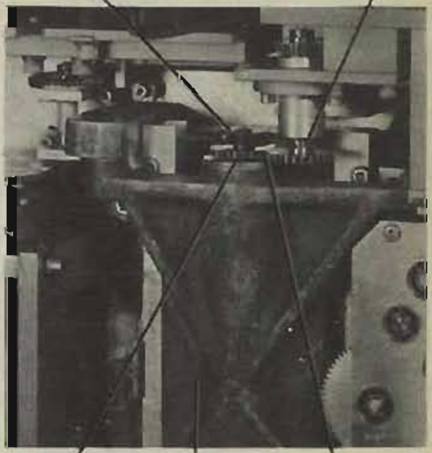
As another example, consider problem 20. Here the calculated value is 283°53′ at the end of 30 seconds. The problem setup form gives *dE* as +152.2 deg./min. For 30 seconds, the value would be +76.1°, representing 7 revolutions of the dial. If the dial makes 7 revolutions and stops at 3°40′, the reading of 28 is copied from the record form for problem results and is followed by the 3°40′ read on the dial. The full entry will then be 283°40′.

The remaining elevation problems are run in the same manner. The errors and the rate errors for each reading and the average and maximum errors for each problem are calculated in the same way as range problem errors and are entered on the B test summary sheet.

The summary average and the summary maximum rate errors are then compared with the given allowable errors.

At the conclusion of the elevation B tests, return the *dR* handcrank to AUTO if it is in HAND.

Reconnect the range integrator if it is disconnected.

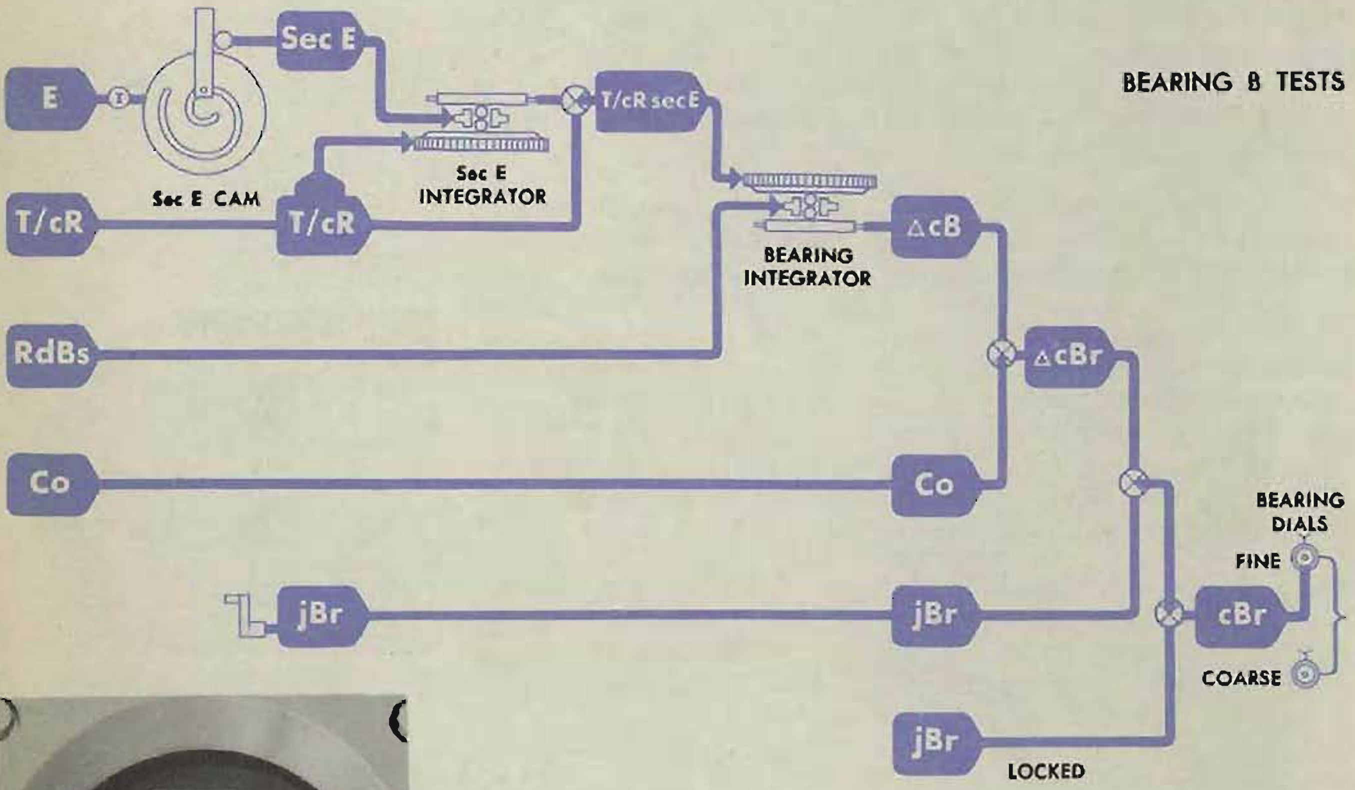


Reconnecting the range integrator

1. Carefully remove the bakelite wedge between the gear and the integrator casting.
2. Loosen clamp A-167. Lower the left gear gently until the gears mesh.
3. Tighten clamp A-167 carefully. Overtightening this clamp may snap the hardened roller output shaft.
4. Replace the plug in cover 1.

BEARING B TESTS

Disconnect the range integrator or establish a zero range rate. Select a reference index on the fine generated bearing dial and mark it as described in elevation B tests. Set the computer dials at the values specified on the bearing B test problem setup form, being especially careful to set *cR* and *E* accurately.



FINE INNER DIAL REFERENCE MARK

Running the bearing tests

Run the bearing B tests, following the procedure used in elevation B tests.

In bearing B tests it is especially important to start and stop the time line gradually because of the added inertia of the bearing filter.

The bearing dial readings are entered on the record form for problem results, and the problem average and maximum errors are calculated in the same way as the elevation errors. The summary average and summary maximum rate errors are then compared with the given allowable errors.

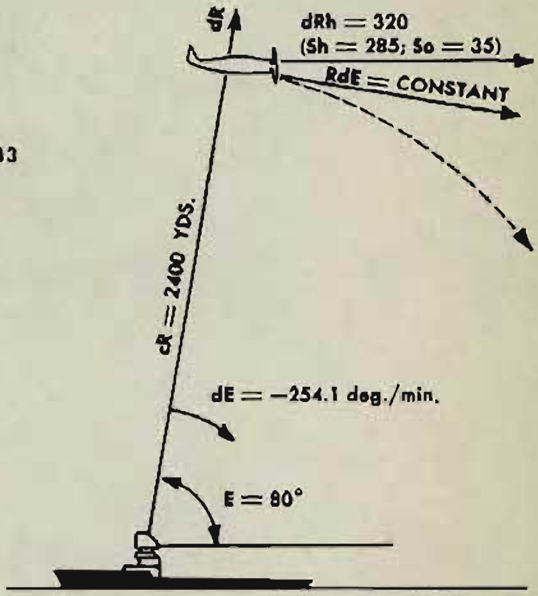
Reconnect the range integrator if it is disconnected. If it is not disconnected, put the *dR* handcrank back to AUTO.

Typical B test problems

The B test problems are designed to test the integrators and do not represent problems encountered in normal operation. Here are diagrams of three typical B test problems: one for range, one for elevation, and one for bearing.

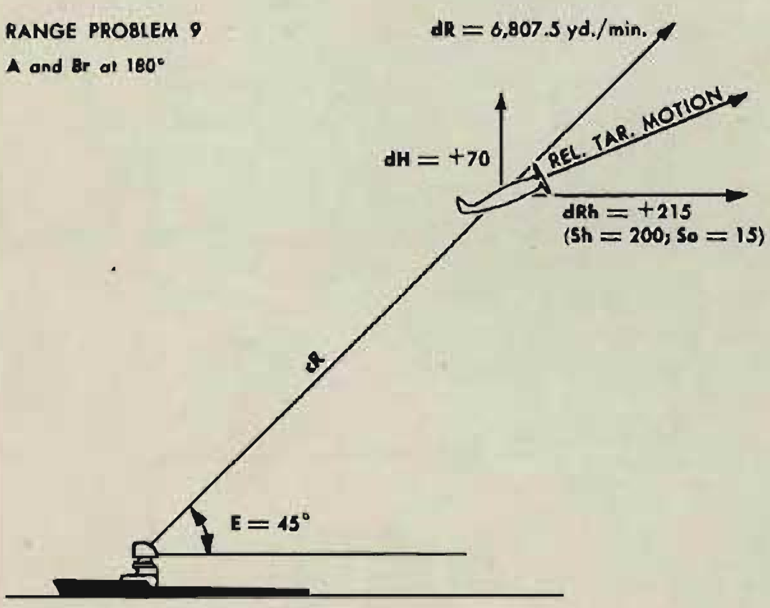
ELEVATION PROBLEM 13

A and Br at 180°
dH = 0



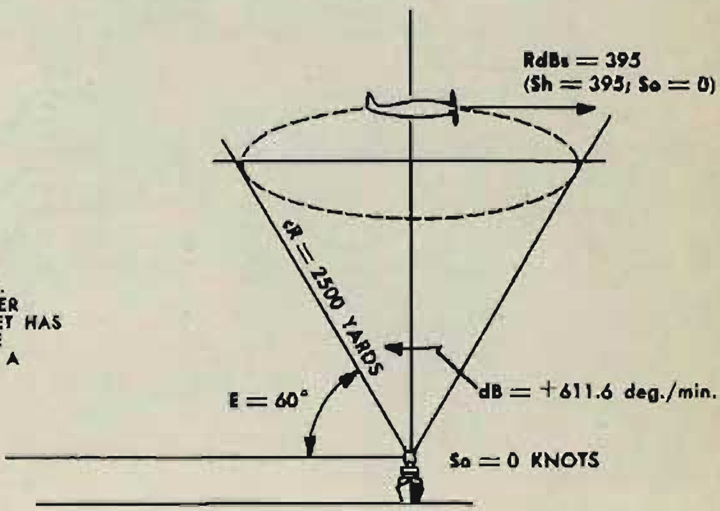
RANGE PROBLEM 9

A and Br at 180°



BEARING PROBLEM 33

TARGET CIRCLES OWN SHIP WHICH IS STATIONARY. TARGET SPEED 395 KNOTS. TARGET BEARING INCREASES 611° 36′ PER MINUTE. AT END OF 3 MINUTES TARGET HAS COMPLETED SLIGHTLY MORE THAN FIVE REVOLUTIONS AROUND OWN SHIP AT A CONSTANT ELEVATION.



C TESTS

What C tests check

The C tests are dynamic tests—that is, running tests. They check the accuracy of the integrator group outputs over a period of time during which the integrator group inputs are continuously changing. The time motor is ON during these tests. The time line drives the integrators, which generate changes of range, elevation, and bearing.

C tests check the adjustment and operation of the mechanisms which compute the relative motion rates and generate the changes of range, elevation, and bearing.

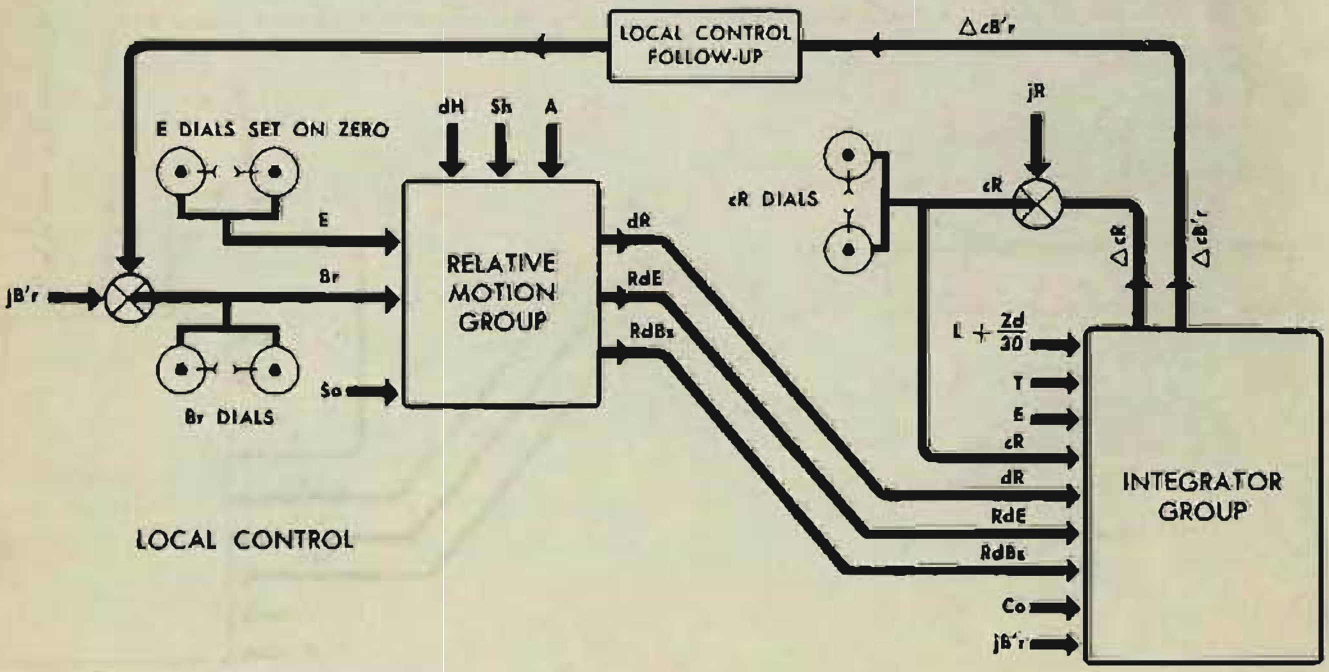
The two types of C test problems

There are two sets of C test problems:

Four problems testing the computer in local control.
Ten problems testing the computer in semi-automatic control.

Problems testing the computer in local control

C test problems 1 through 4 are run in local control. They are surface problems. Elevation is set at 0°00′, and only changes of range and bearing are tested.



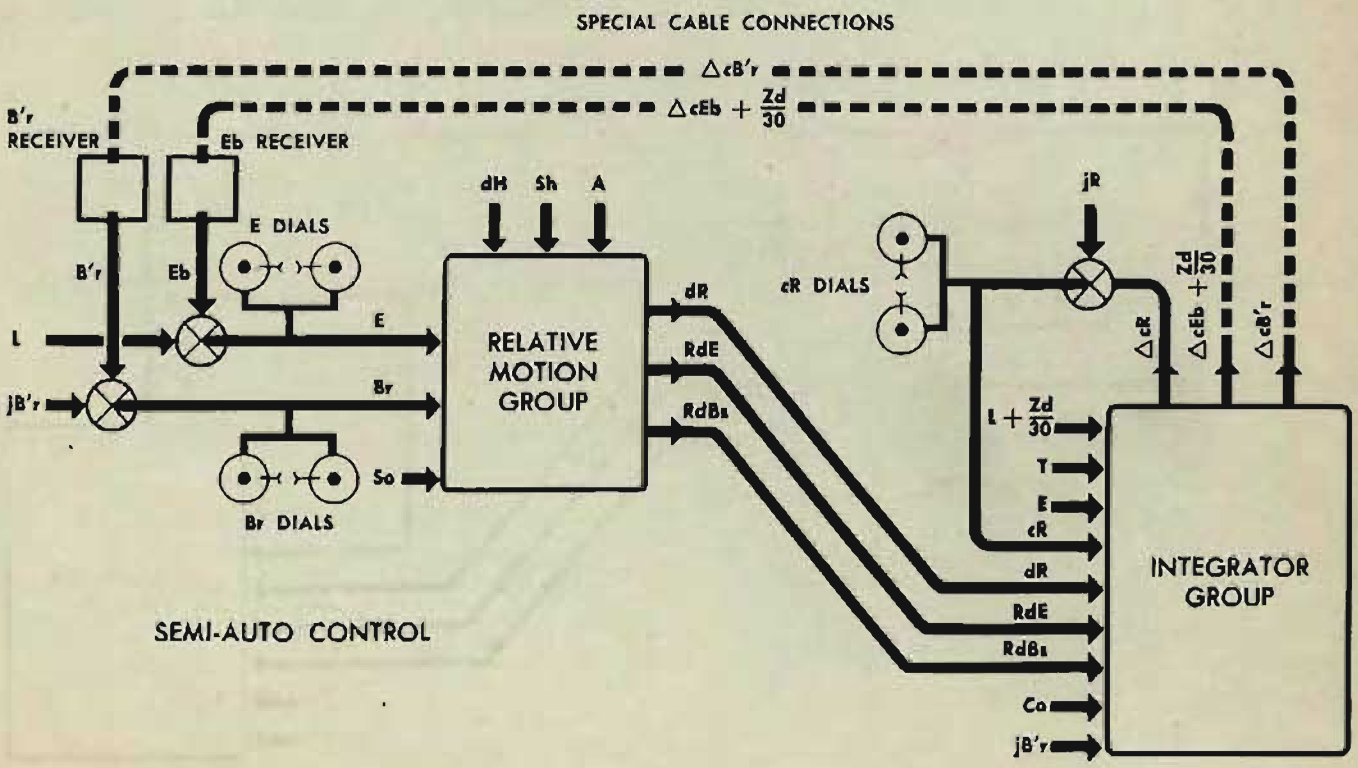
LOCAL CONTROL

Problems testing the computer in semi-automatic control

Problems 5 through 14 are run in semi-auto control. Two of these are surface problems, and the remainder are air problems.

Special electrical connections are needed to run the problems in semi-auto control.

At the discretion of the gunnery officer, these problems may be run as a system test, using the director instead of the special connections. When the director is used, the test merely constitutes a check of the system, because the errors are not entirely chargeable to the Computer Mark 1. Such errors may be greater than the limits allowed for the computer alone, even though the computer is in satisfactory condition.



C TEST RECORD FORMS

All the information necessary for running the C test problems is given on the C test problem record forms ORD SK 104371–43 to 50 inclusive.

There are two C test summary record forms: one for problems 1 through 4, on which only bearing and range errors are recorded; and another for problems 5 through 14, on which bearing, elevation, and range errors are recorded.

All C test record forms should be filled out completely, dated, and filed for future reference.

PROBLEM RECORD FORM

C TEST PROBLEM 2

TIME	BEARING					RANGE				
	CALC.	READ.	ERROR	RATE ERRORS		CALC.	READ.	ERROR	RATE ERRORS	
				DIFF. ERROR	ERROR TIME				DIFF. ERROR	ERROR TIME
MINUTES SECONDS	DEGREES MINUTES	DEGREES MINUTES	MINUTES	MINUTES PER MIN.	MINUTES PER MIN.	YARDS	YARDS	YARDS	YARDS PER MIN.	YARDS PER MIN.
0:00	180°00'	180°00'	0			5000	5000	0		
0:30	180°00'					5338				
1:00	180°00'					5676				
1:30	180°00'					6013				
2:00	180°00'					6351				
2:30	180°00'					6689				
3:00	180°00'					7027				
3:30	180°00'					7364				
4:00	180°00'					7702				
4:30	180°00'					8040				
5:00	180°00'					8378				
SUM						SUM				
AVERAGE						AVERAGE				
MAXIMUM						MAXIMUM				

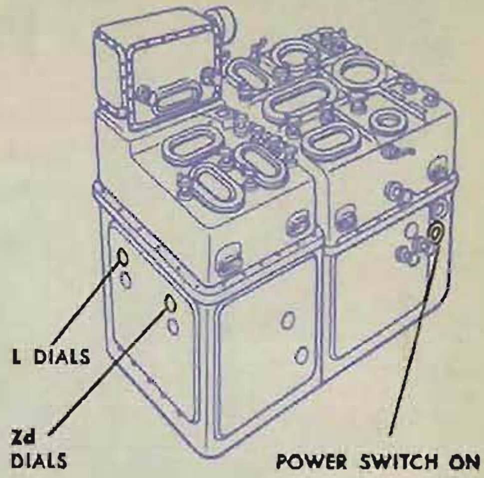
SET: L at 2000' Zd at 2000' E at 0° A at 180°
dH at 10 KNOTS Sh at 10 KNOTS Co at 90° So at 10 KNOTS
Br and cR at INITIAL VALUES
CONTROL SWITCH at LOCAL
SYNCHRONIZE ELEVATION HANDCRANK at CENTER

SUMMARY RECORD FORM

SUMMARY OF RESULTS

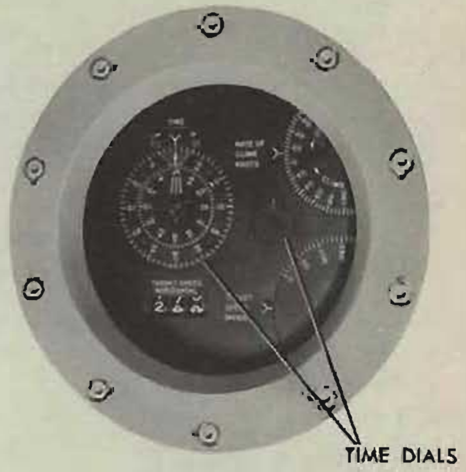
PROBLEM NO.	BEARING RATE ERRORS Minutes per minute				RANGE RATE ERRORS Yards per minute			
	DIFFERENCE ERROR		ERROR TIME		DIFFERENCE ERROR		ERROR TIME	
	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM
1								
2								
3								
4								
SUM		—		—		—		—
AVERAGE		—		—		—		—
MAXIMUM	—		—		—		—	
ALLOWABLE AVG.	25	—	25	—	30	—	30	—
ALLOWABLE MAX.	—	75	—	75	—	90	—	90

PRELIMINARY SETUP FOR ALL C TEST PROBLEMS



1 Turn the power switch ON.
2 Set level, *L*, at 2000′ on the computer dials.
3 Set cross-level, *Zd*, at 2000′ on the computer dials.
4 Set the time dials on 0.

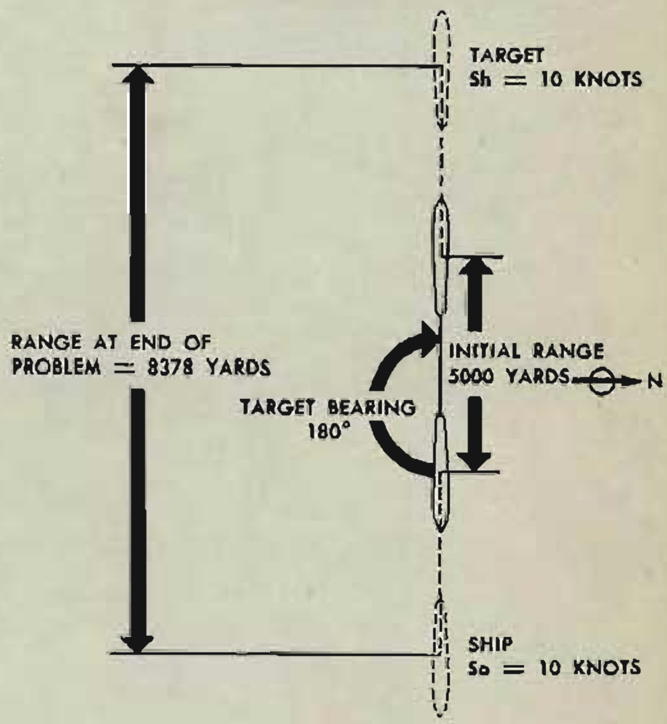
Time in C tests is the same as time in B tests. It is represented by the revolutions of the time line as registered on the time dials.



Each problem begins at the moment that the time dials move off 0.

The speed of the time line must be worked up gradually with the time crank OUT, before the time motor switch is turned ON.

If the time line is not turning at approximately normal running speed when the time motor is turned ON, excessive slippage may occur in the integrators before the inertia of the line is overcome.



C TEST PROBLEM 2

If the time dials are turned beyond the required reading, do not turn them back. Set the time dials on 0 and repeat the problem. Turning the time line backward may damage the time motor regulator, and will introduce additional errors in the tests.

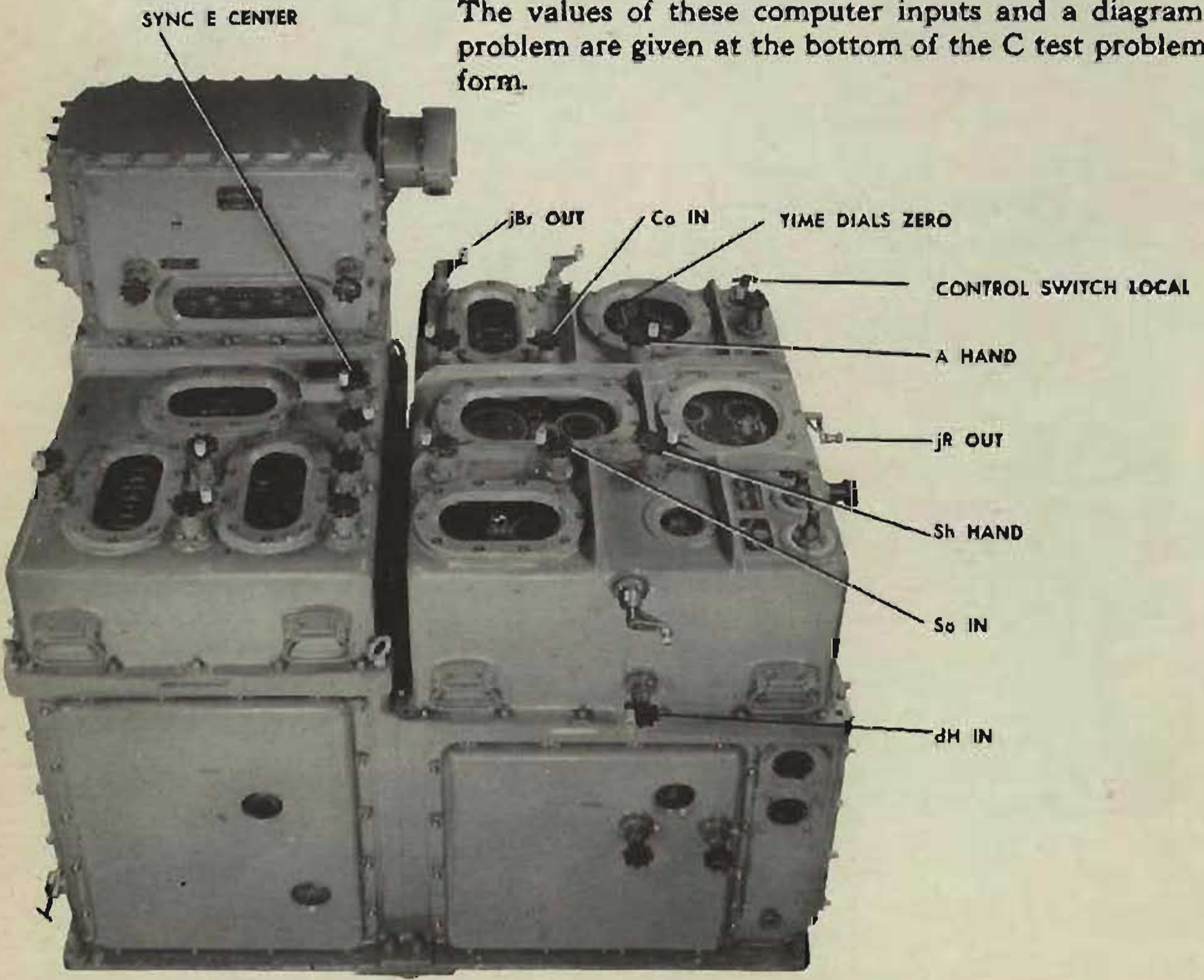
PROBLEMS 1 THROUGH 4

Problems 1 through 4 are surface problems which test the group of mechanisms that generate changes of range and bearing.

Setting up the computer for problem 1

1. Check that the time dials are on 0.
2. Turn the control switch to LOCAL.
3. Set *E* at 0°00′ with the sync *E* handcrank in the CENTER position. The handcrank should remain in the CENTER position throughout the problems.
4. Set *dH* at 0, with the rate of climb handcrank IN.
5. Put the ship course handcrank IN.
6. Set initial *jBr* on 284°00′, with the generated bearing crank OUT.
7. Set *A* at 14°, with the target angle handcrank at HAND.
8. Set *Sh* at 30 knots, with the target speed handcrank at HAND.
9. Set *So* at 30 knots, with the ship speed handcrank IN.
10. Set initial *cR* at 14,000 yards, with the generated range crank OUT.

The values of these computer inputs and a diagram of the problem are given at the bottom of the C test problem record form.



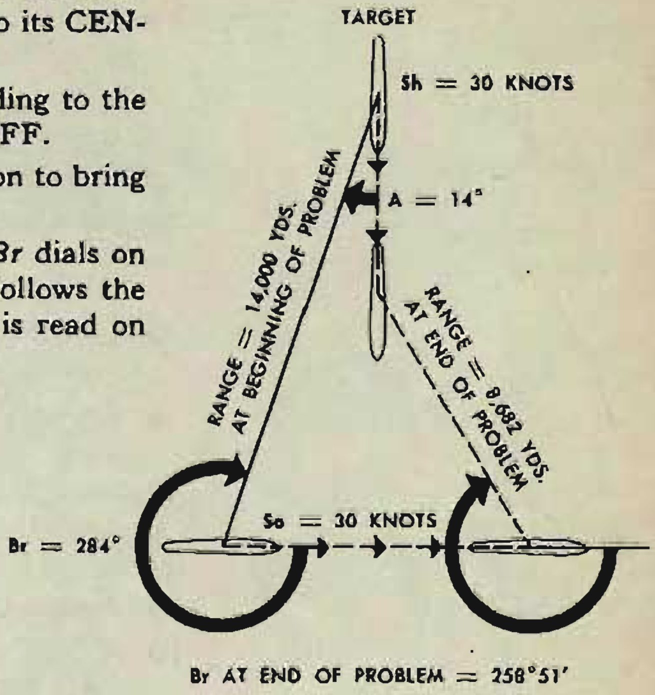
Running problem 1

1 Gradually work up speed in the time motor by turning the time crank in the OUT position. Then turn the time motor switch ON and return the time crank to its CENTER position.

2 Run the problem for about 25 seconds according to the time dials. Then turn the time motor switch OFF.

3 Slowly turn the time crank in the OUT position to bring the time dials to a stop at exactly 30 seconds.

4 Record the readings of the *cR* dials and the *Br* dials on the problem form. In all C tests the *Br* dial follows the movement of the *cBr* dial; therefore bearing is read on the *Br* ring dials against the fixed index.



C TEST PROBLEM 1

Continue the problem until the time dial reading is 1:00 minute, and then record the second set of readings. Complete the problem and record the dial readings at each time interval specified on the problem record form.

Problems 2, 3, and 4 are run and recorded in the same way.

TIME	BEARING Br					RANGE cR				
	CALC.	READ.	ERROR	RATE ERROR MIN./MIN.		CALC.	READ.	ERROR	RATE ERROR YDS./MIN.	
MIN. & SEC.	DEG. & MIN.	DEG. & MIN.	MIN.	DIFF. ERRORS	ERROR TIME	YDS.	YDS.	YDS.	DIFF. ERRORS	ERROR TIME
C TEST NO. 1										
0:00	284°0'	284°0'	0			14000	14000	0		
0:30	282°25'					13391				
1:00	280°42'					12793				
1:30	278°48'					12208				
2:00	276°43'					11637				
2:30	274°25					11084				
3:00	271°53'					10550				
3:30	269°5'					10039				
4:00	266°0'					9554				
4:30	262°36'					9100				
5:00	258°51'					8682				
TOTAL						TOTAL				
AVG. RATE ERROR						AVG. RATE ERROR				
MAX. RATE ERROR						MAX. RATE ERROR				

COMPUTING ERRORS IN C TESTS

The mechanisms that generate changes in range and bearing are in satisfactory adjustment when the errors come within the allowable limits given on the C test summary record form for problems 1 through 4.

The errors are the differences between the recorded readings of *cR* and *Br* and the mathematically calculated values of *cR* and *Br*.

The allowable limits are based on average and maximum rate errors.

Errors

These errors are obtained by algebraic subtraction. The calculated value is subtracted from the observed reading. It is necessary to record the signs of the errors, because they are used in computing the difference errors and also in analyzing excessive errors.

Rate errors

There are two types of rate errors in C tests, difference errors and error/time rate errors.

A difference error is the difference between the errors for readings taken one minute apart. Where readings are taken at 30-second intervals, the first difference error to be recorded is the difference between the error at the start of the problem and the error at the second reading, which is after a one-minute interval. The second difference error is the difference between the error at the first reading and the third reading.

TIME	BEARING Br					RANGE cR				
	CALC.	READ.	ERROR	RATE ERROR MIN./MIN.		CALC.	READ.	ERROR	RATE ERROR YDS./MIN.	
MIN. & SEC.	DEG. & MIN.	DEG. & MIN.	MIN.	DIFF. ERRORS	ERROR / TIME	YDS.	YDS.	YDS.	DIFF. ERRORS	ERROR / TIME
C TEST NO. 1										
0:00	284°0'	284°0'	0			14000	14000	0		
0:30	282°25'					13391				
1:00	280°42'					12793				
1:30	278°48'					12208				
2:00	276°43'					11637				
2:30	274°25'					11084				
3:00	271°53'					10550				
3:30	269°5'					10039				
4:00	266°0'					9554				
4:30	262°36'					9100				
5:00	258°51'					8682				
TOTAL						TOTAL				
AVG. RATE ERROR						AVG. RATE ERROR				
MAX. RATE ERROR						MAX. RATE ERROR				

Gene Slover's US Navy Pages Table of Contents

The error/time rate error is computed by dividing the error by the time *in minutes* that has elapsed since the beginning of the problem.

Average errors

The average error for the problem is computed by adding each column of rate errors and dividing the sum by the number of rate errors recorded.

Maximum errors

The maximum error is the largest error of each group.

Compute the errors for each of the first four problems. Record the problem averages and maximums on the C test summary record form for problems 1 through 4. Compute and record the sums and averages and record the maximum in each column; compare these results with the allowable averages and maximum given.

The four surface problems are satisfactory when:

average bearing rate errors are below 25,
maximum bearing rate errors are below 75,
average range rate errors are below 30,
maximum range rate errors are below 90.

If the errors exceed the allowable limits, refer to the chapter on C test analysis to locate and correct the errors.

SUMMARY OF RESULTS								
PROBLEM NO.	BEARING RATE ERRORS Minutes per minute				RANGE RATE ERRORS Yards per minute			
	DIFFERENCE ERROR		ERROR / TIME		DIFFERENCE ERROR		ERROR / TIME	
	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM	AVERAGE	MAXIMUM
1								
2								
3								
4								
SUM		—		—		—		—
AVERAGE		—		—		—		—
MAXIMUM	—		—		—		—	
ALLOWABLE AVG.	25	—	25	—	30	—	30	—
ALLOWABLE MAX.	—	75	—	75	—	90	—	90

PROBLEMS IN SEMI-AUTO CONTROL

Without using the director

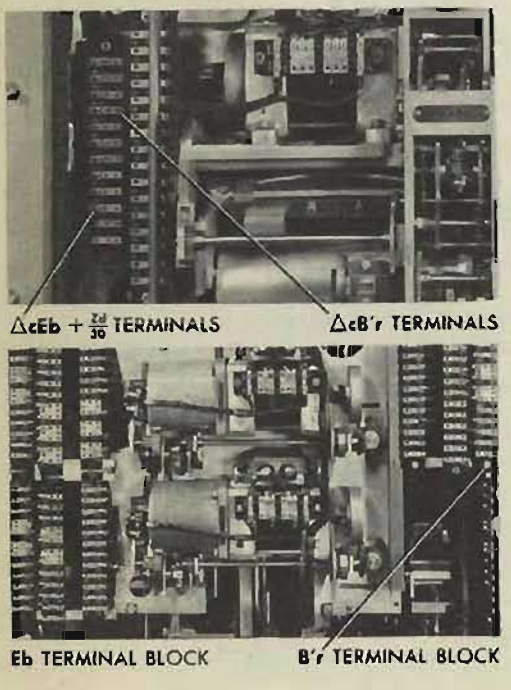
In local control the observed and the generated dials turn together. It is possible to read the initial value plus the generated changes on the observed dials. In semi-auto control the observed and generated dials do not turn together. The generated changes are transmitted to the director where they correct the initial values. The initial value plus the generated changes then registers on the observed dials.

C test problems 5 through 14 are run in semi-automatic control. In normal semi-automatic operation, the computer outputs transmitted to the director change the computer inputs received from the director. In order to eliminate the director, the computer is made regenerative; that is, the computer outputs are fed back directly into the computer inputs. Special test cable connections are used for this purpose.

These cable connections allow generated bearing and elevation to be transmitted directly to the bearing and elevation receivers. No special range connections are needed, since range is regenerative within the computer.

The transmitters and receivers must be disconnected from the director before the special cable connections can be made.

Disconnecting director wiring



1 Disconnect the ship's wiring from the stators of both the bearing correction and the elevation correction indicating transmitters.

2 Disconnect the ship's wiring from the coarse and fine stators of the director train and the director elevation receivers.

Do *not* disconnect the ship's wiring to the rotor supply, because the transmitter and receiver synchros can be energized at the fire control switchboard only if the rotor wiring is connected.

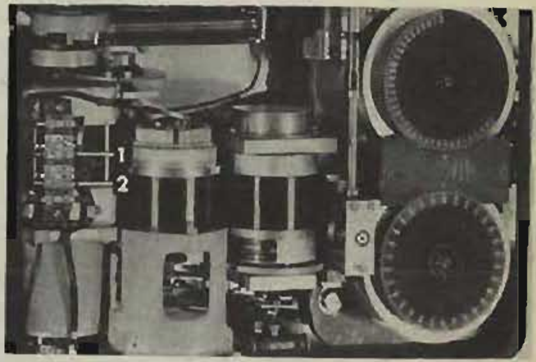
Wiring designation charts inside covers 4 and 7 will indicate which wires should be disconnected from the terminal blocks.

Only the fine receivers should be connected. The coarse controls must therefore be de-energized.

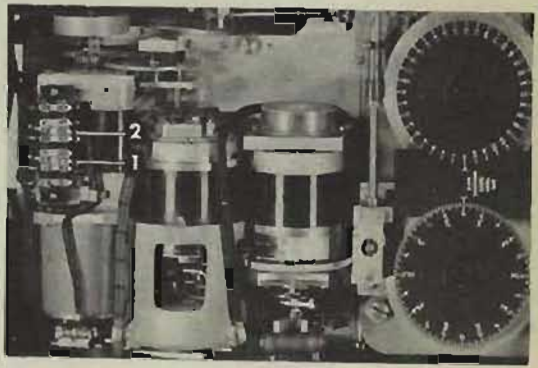
1 Disconnect leads 1 and 2 on the director train and director sight elevation receivers.

2 Place a small rubber band around the outer edge of the scissor arms of each coarse control to keep the interrupter contacts closed throughout the test.

Eb LEADS AND TERMINALS



B'r LEADS AND TERMINALS



Making the cable connections

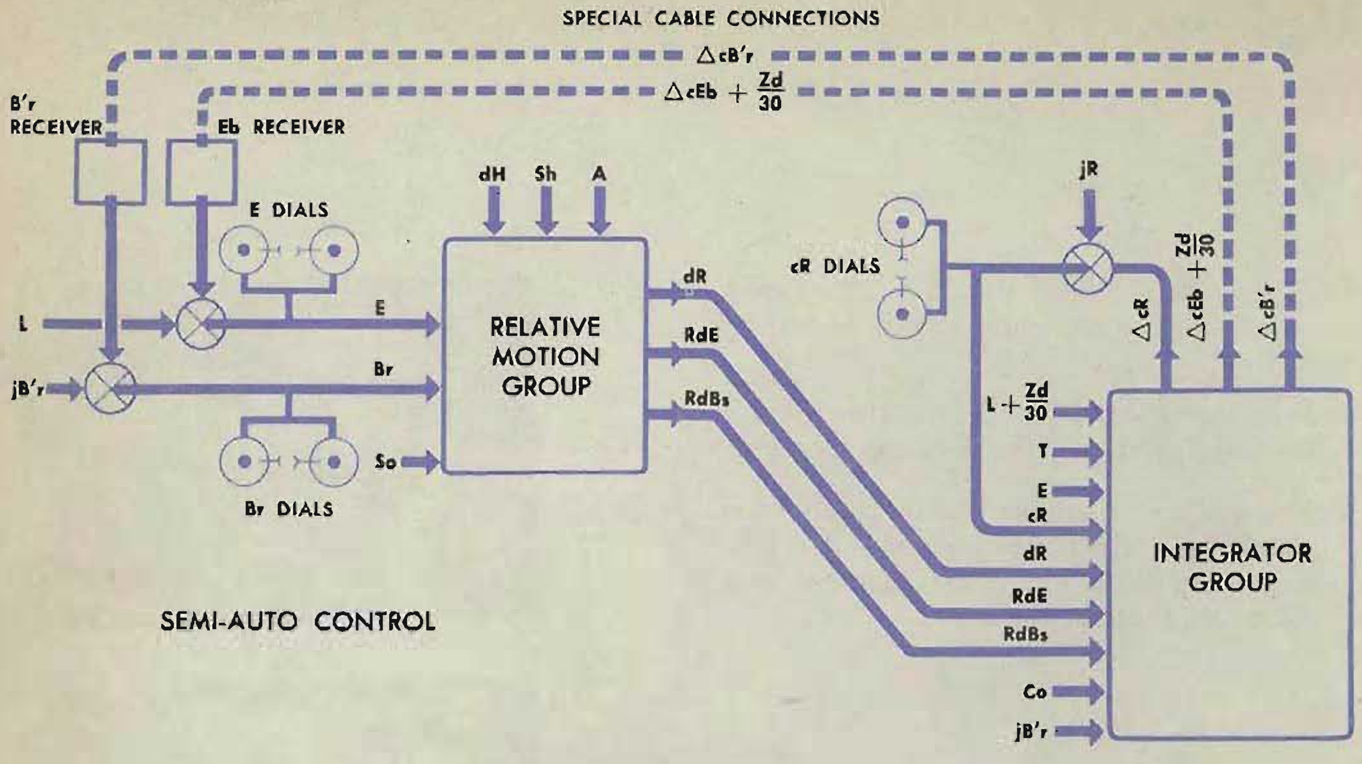
Use jumpers to connect the bearing correction indicating transmitter to the director train receiver:

Connect S1 to S3 FINE
Connect S2 to S2 FINE
Connect S3 to S1 FINE

NOTE:
Since the rotors of the two motors which are to be connected turn in opposite directions, the connections are reversed.

Connect the elevation correction indicating transmitter to the director sight elevation receiver:

Connect S1 to S1 FINE
Connect S2 to S2 FINE
Connect S3 to S3 FINE



PROBLEMS 5 THROUGH 14

The computer is regenerative when the elevation and bearing cable connections are made.

The sum of integrator outputs and initial values can be read directly on the range, elevation, and bearing dials. In this way, the tracking section is tested.

During the tests the time line is turned by the time motor and the time crank, as previously explained. Readings of the range, elevation, and bearing dials are recorded at given time intervals. The readings are then compared to the calculated values on the problem record forms.

TIME	BEARING Br					ELEVATION E					RANGE cR				
	CALC.	READ.	ERR.	RATE ERROR MIN./MIN.		CALC.	READ.	ERR.	RATE ERROR MIN./MIN.		CALC.	READ.	ERR.	RATE ERROR YDS./MIN.	
				DIFF. ERR-ORS	ERR-OR TIME				DIFF. ERR-ORS	ERR-OR TIME				DIFF. ERR-ORS	ERR-OR TIME
MIN. & SEC.	DEG. & MIN.	DEG. & MIN.	MIN.			DEG. & MIN.	DEG. & MIN.	MIN.			YDS.	YDS.	YDS.		
C TEST NO. 5															
0:00	0°0'	0°0'	0			0°0'	0°0'	0			14000	14000	0		
0:30	0°0'					0°0'					12818				
1:00	0°0'					0°0'					11636				
1:30						0°0'					10453				
						0°0'					[illegible]271				
3:30	0°0'														
4:00	0°0'					[illegible]					4542				
4:30	0°0'					0°0'					3360				
TOTAL						TOTAL					TOTAL				
AVG. RATE ERROR						AVG. RATE ERROR					AVG. RATE ERROR				
MAX. RATE ERROR						MAX. RATE ERROR					MAX. RATE ERROR				

PRELIMINARY SETUP FOR PROBLEMS 5 THROUGH 14

1 Turn the power ON.

2 Energize the bearing and elevation correction transmitters at the switchboard.

3 Energize the *Eb* and *B'r* receivers at the switchboard.

4 Set *L* and *Zd* at 2000'.

Setting up the computer for problem 5

1 Set *Co* at 270°, with the ship course handcrank in the IN position.

2 Set *Br* on 0°00' as follows:
- a Turn the control switch to LOCAL. Turn the generated bearing crank in the OUT position until *Br* reads 0°00'.
- b Turn the control switch to SEMI-AUTO. The bearing dials will run off the setting by some amount up to 5°.
- c Offset *Co* enough to reposition the bearing dials on the setting.

NOTE: The value of *Co* actually has no effect on C test problems.

3 Set *E* at 0°00' as follows:
- a Turn the sync *E* handcrank in the CENTER position until *E* is set at 0°00'.
- b Pull the sync *E* handcrank to the OUT position. Match the sync *E* dials at the index.
- c Turn the power OFF.
- d Push the sync *E* handcrank to the IN position.
- e Turn the power ON.
- f The elevation dials will run off the setting some amount up to 5°.
- g With the sync *E* handcrank still in the IN position, offset the sync *E* dials enough to reposition the elevation dials on the setting.

NOTE: The sync *E* dials should be approximately matched to prevent the *Eb* shaft line from running into its limit stop during the test.

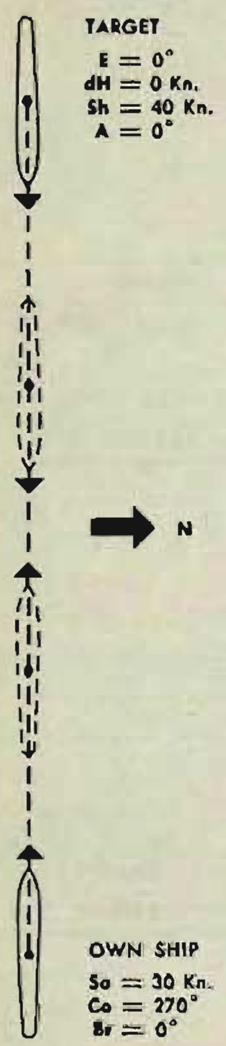
4 Set *A* at 0°, with the target angle handcrank in the HAND position.
NOTE: Target angle must be set at the initial value as accurately as possible to obtain satisfactory C test results.

5 Set *Sh* at 40 knots, with the target speed handcrank in the HAND position.

6 Set *dH* at 0 knots, with the rate of climb handcrank in the IN position.

7 Set *So* at 30 knots, with the ship speed handcrank in the IN position.

8 Set *cR* at 14,000 yards, with the generated range crank in the OUT position.



Running problem 5

1. Gradually work up speed in the time motor by turning the time crank in the OUT position.
2. Turn the time motor switch ON. Return the time crank to the CENTER position.
3. Run the problem for about 25 seconds according to the time dials. Then turn the time motor switch OFF.
4. Slowly turn the time crank in the OUT position, bringing the time dials to a stop at exactly 30 seconds.
   Record the readings of the *cR*, *Br*, and *E* dials on the problem record form.

Continue the problem until readings have been recorded for each time dial reading given. Compute the errors and rate errors of each quantity tested. Run problems 6 through 14 in the same manner.

Setting up and running problem 14

In this problem, changes occur in all three generated values: bearing, elevation, and range. In problem 5, a surface problem, elevation remains constant.

To set up problem 14, set in the initial values given on the C test record form for problem 14. Use the same switches and handcranks in the positions described for problem 5.

Run problem 14 in the same manner as problem 5 and compute the errors.

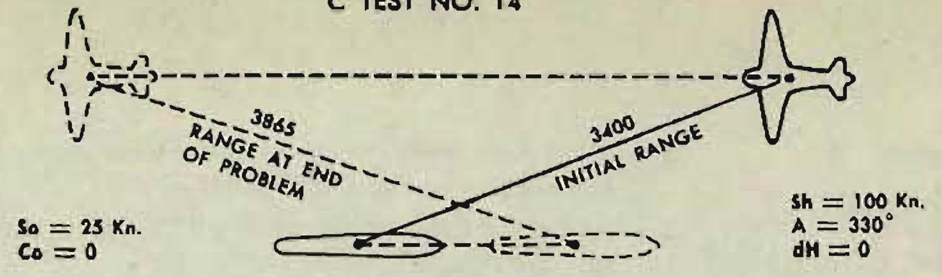
COMPUTING THE ERRORS

Record the average and maximum errors for each problem on the C test summary record form for problems 5 through 14.

Compute the overall (summary) averages and maximums for all problems in the manner described for problems 1 through 4. Compare these errors with the allowable limits.

If the average and maximum errors exceed the allowable limits given on the summary record form, refer to the chapter on C test analysis.

C TEST NO. 14



	BEARING Br					ELEVATION E					RANGE cR				
TIME MIN. & SEC.	CALC. DEG. & MIN.	READ. DEG. & MIN.	ERR. MIN.	DIFF. ERR. MIN./MIN.	ERR. TIME MIN./MIN.	CALC. DEG. & MIN.	READ. DEG. & MIN.	ERR. MIN.	DIFF. ERR. MIN./MIN.	ERR. TIME MIN./MIN.	CALC. YDS.	READ. YDS.	ERR. YDS.	DIFF. ERR. YDS./MIN.	ERR. TIME YDS./MIN.
0:00	330°00'	330°00'	0			10°00'	10°00'	0			3400	3400	0		
0:10	322°41'					12°04'					2825				
0:20	311°43'					14°46'					2319				
0:30	295°13'					17°42'					1943				
0:40	272°54'					19°24'					1777				
0:50	249°43'					18°18'					1880				
1:00	231°42'					15°28'					2214				
1:10	219°34'					12°40'					2694				
1:20	211°31'					10°27'					3256				
1:30	206°00'					8°47'					3866				
	TOTAL					TOTAL					TOTAL				
	AVG. RATE ERROR					AVG. RATE ERROR					AVG. RATE ERROR				
	MAX. RATE ERROR					MAX. RATE ERROR					MAX. RATE ERROR				

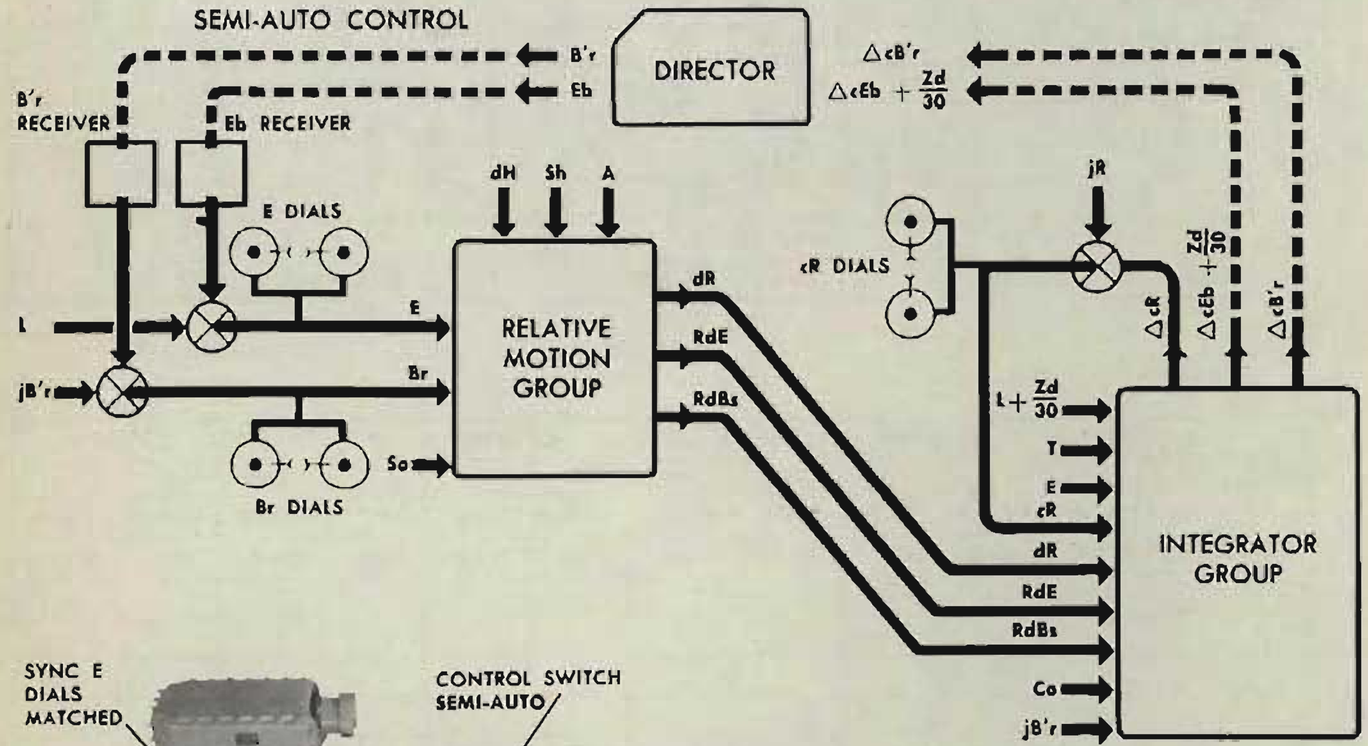
C TEST NO.	BEARING RATE ERRORS MIN./MIN.				ELEVATION RATE ERRORS MIN./MIN.				RANGE RATE ERRORS MIN./MIN.			
	DIFF. ERRORS		ERROR/TIME		DIFF. ERRORS		ERROR/TIME		DIFF. ERRORS		ERROR/TIME	
	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.	AVG.	MAX.
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
OVERALL AVG. & MAX. RATE ERRORS, C TESTS 5-14												
ALLOW. OVER-ALL	33	99	33	99	33	99	33	99	30	90	30	90

RUNNING THE PROBLEMS AS A SYSTEM TEST

Relative target bearing, *Br*, and target elevation, *E*, are set into the computer by setting director train, *B'r*, and director sight elevation, *Eb*, at the director, with the selector lever in AUTO control. Director train and director sight elevation are transmitted electrically to the computer. All other inputs are set in by hand at the computer.

The system test checks the outputs from the integrator group as well as the transmission of bearing and elevation quantities between the director and the computer.

The time line is turned by the time crank and the time motor, as previously described. Readings on the range, elevation, and bearing dials are recorded at given time intervals. They are compared to the calculated values given on the problem record forms.



Preliminary setups for problems 5 through 14

To set up the computer for problems 5 through 14:

1. Turn the control switch to SEMI-AUTO.
2. Match the indexes on the sync *E* dials with the sync *E* handcrank in the IN position.
3. Set *L* and *Zd* at 2000'.

Setting up the computer for problem 5

1 Set *Co* at 270°, with the ship course handcrank in the IN position.

2 Set elevation, *E*, on 0°00′ at the director.

3 Set relative target bearing, *Br*, on 0°00′, by setting director train, *B′r*, on 0°00′ at the director.

4 Set *A* at 0°, with the target angle handcrank in the HAND position.

5 Set *Sh* at 40 knots, with the target speed handcrank in the HAND position.

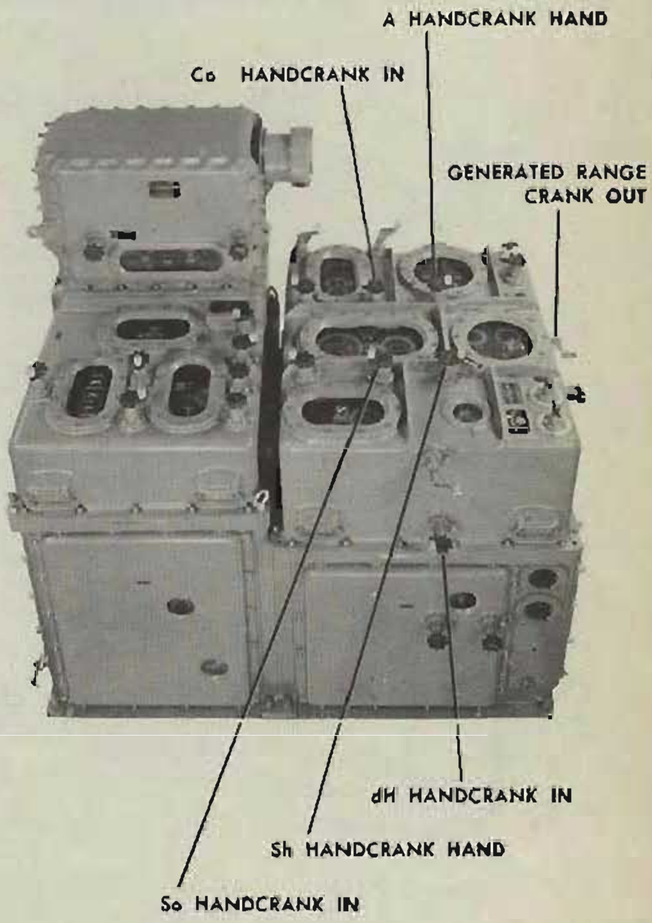
6 Set *dH* at 0 knots, with the rate of climb handcrank in the IN position.

7 Set *So* at 30 knots, with the ship speed handcrank in the IN position.

8 Set *cR* at 14,000 yards, with the generated range crank in the OUT position.

CAUTION:
The director handwheels must not be turned while these tests are run.

Run the problems and record the results in the manner previously described.



Computing errors

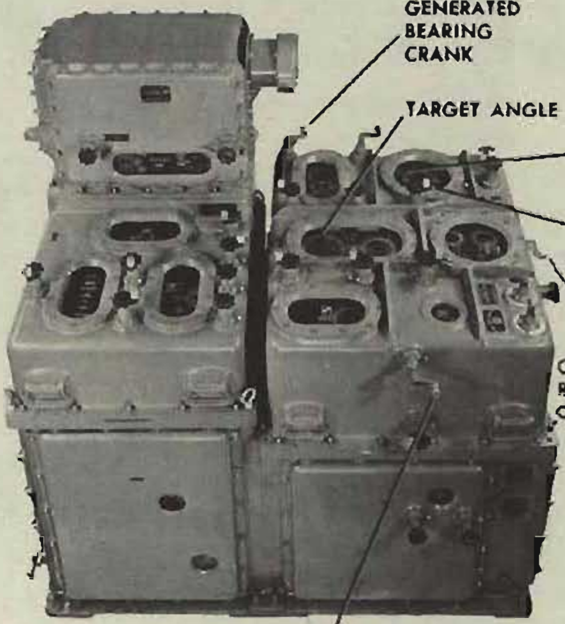
Record the average and maximum error for each problem on the C test summary record form for problems 5 through 14. Compute the summary averages and maximums for all problems in the manner described for the LOCAL CONTROL problems. Compare these summary errors with the allowable limits.

Note that the errors obtained from the system test include possible director and transmission errors in addition to any computer errors. The allowable limits on the summary record form *are based on errors occurring in the computer only*. Therefore, if the errors are *considerably beyond* the allowable limits, refer to the chapter on C test analysis.

RATE CONTROL TESTS

What is tested

The rate control tests are a means of checking the proper functioning of the rate control system. The mechanisms of this section correct the original estimates of target angle, *A*, target speed, *Sh*, and rate of climb, *dH*.



How the tests are run

Specified changes of generated range, generated elevation, and generated bearing are made in order to introduce computed rate corrections into the rate control mechanisms. The effect of these rate corrections on *A*, *Sh*, and *dH* is observed. The computed changes in these quantities are then compared with mathematically calculated changes.

The rate control tests may be run either in semi-automatic or in automatic control. The necessary information and test data are given in the rate control test form, NAVORD Form 1229.

SEMI-AUTO RATE CONTROL TESTS

1 Turn the power switch ON. Leave the time motor OFF.

2 Turn the control switch to SEMI-AUTO.

3 Turn the range rate control switch to MANUAL.

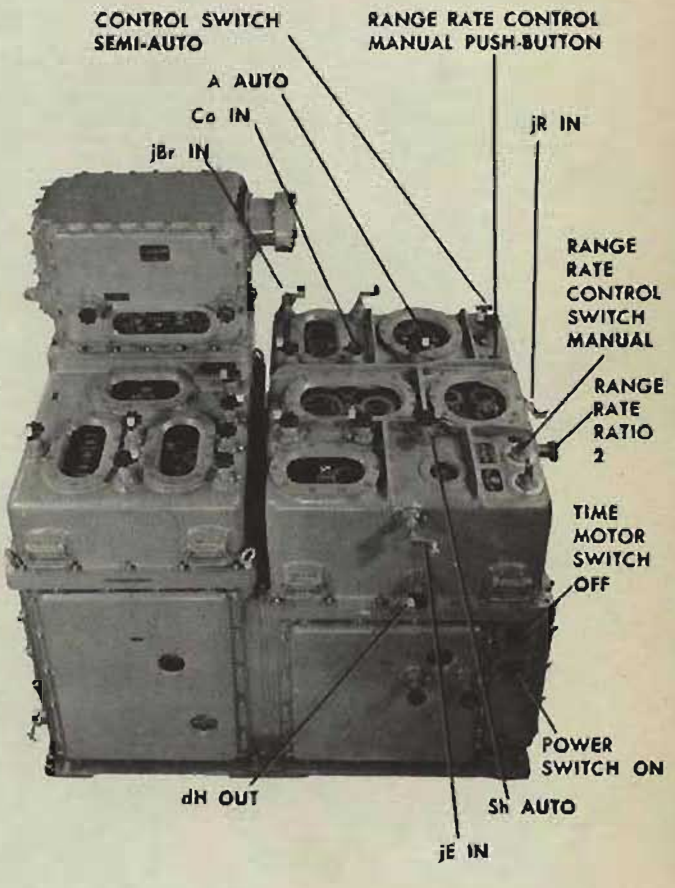
4 Put the target speed and target angle handcranks in AUTO.

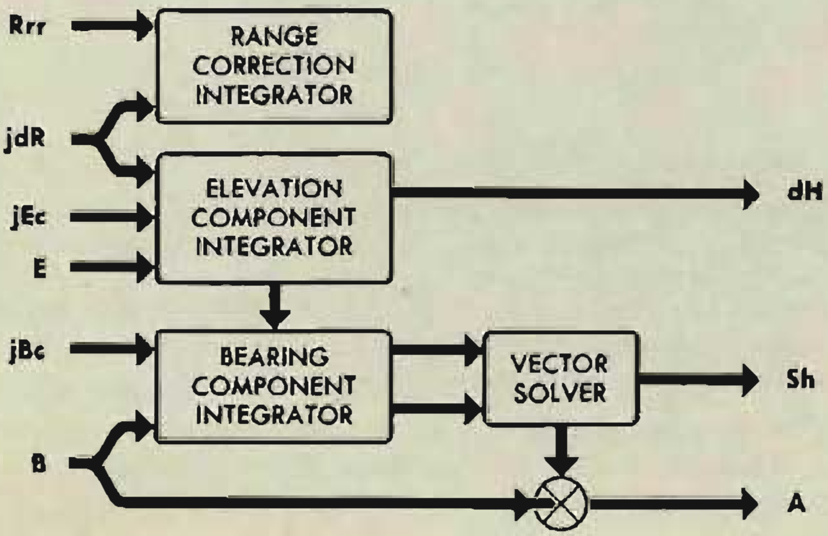
5 Pull the rate of climb handcrank OUT.

6 Lock the generated range, generated elevation, and generated bearing cranks in the IN position.

7 Set the range rate ratio knob at 2. Make certain the knob is engaged. To check this, observe that the limit stop acts at 1 or 5.

In any range rate correction problem, the setting of the range rate ratio knob may be changed ± 0.2 to reduce the error to the allowable limit.





Running the tests

Whenever changes of generated range are introduced, the range rate control manual push-button must be depressed.

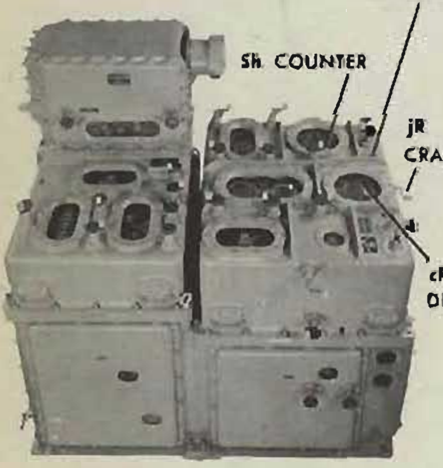
Changes of generated range, generated elevation, and generated bearing feed into the vector solver. These changes must be made *slowly* in order to obtain the full output of the limited *Sh* and *Ct* follow-ups.

OPERATION	E = 0°		E = 80°	
	A = 0°	A = 90°	A = 180°	A = 270°
INCREASE cR 450 YDS.	Sh DEC.	A INC	dH INC.	dH INC.
DECREASE cR 450 YDS.	Sh INC.	A DEC.	dH DEC.	dH DEC.
INCREASE cE 2°00'	dH INC.	dH INC.	Sh DEC.	A INC.
DECREASE cE 2°00'	dH DEC.	dH DEC.	Sh INC.	A DEC.
INCREASE cBr 2°00'	A INC.	Sh INC.	A DEC.	Sh DEC.
DECREASE cBr 2°00'	A DEC.	Sh DEC.	A INC.	Sh INC.

THE RESULTING CHANGES IN Sh AND dH SHOULD BE 88 ± 5 KNOTS

Set *E* at 0°.
Set *A* at 0° by one of the following methods:

1 Depress the target course indicator INCREASE or DECREASE push-button.
2 Shift the target angle handcrank to HAND. Make the required setting. Then return the handcrank to the AUTO position.
3 Set *A* by rate-controlling.



To make computation easier, set *Sh* at either 200 or 300 knots by one of the following methods:

1 Set the target speed switch to increase or decrease *Sh*.
2 Shift the target speed handcrank to HAND. Make the required setting. Then return the handcrank to the AUTO position.
3 Set *Sh* by rate-controlling.

Making changes of generated range

Turn the generated range crank, *without* depressing the range rate control manual push-button, until *cR* reads some even value at the fixed index.

Read the *Sh* counter.

Depress the range rate control manual push-button and *slowly increase cR* 450 yards. *Sh* should decrease 88 (±5) knots.

Depress the manual push-button and *slowly decrease cR* 450 yards. *Sh* should increase 88 (±5) knots.

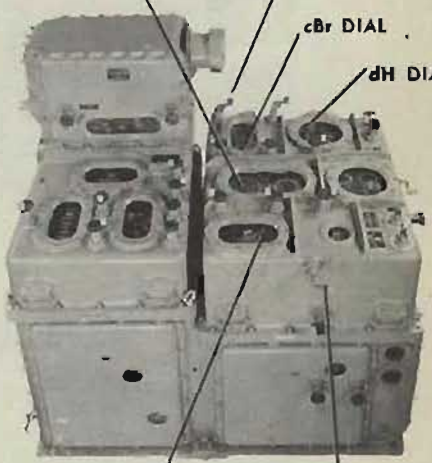
Gene Slover's US Navy Pages | Table of Contents

Making changes of generated elevation

Pull the generated elevation crank OUT against spring pressure. Match one of the graduations of the inner fine elevation dial against the fixed index. Release the handcrank to its IN position.
Read the *dH* dial.
Slowly increase *cE* 2°00′, using the generated elevation handcrank in the IN position. *cE* is increasing when the inner fine dial turns clockwise.
dH should increase 88 (±5) knots.
Decrease *cE* 2°00′.
dH should decrease 88 (±5) knots.

Making changes of generated bearing

Pull the generated bearing crank OUT against its spring pressure. Match one of the graduations on the inner fine bearing dial against the fixed index. Release the handcrank to its IN position.
Target angle should be 0°.
Using the generated bearing crank in the IN position, *slowly increase cBr* 2°00′. *cBr* is increasing when the inner fine dial turns counterclockwise.
Target angle should increase.
Decrease *cBr* 2°00′.
Target angle should decrease.



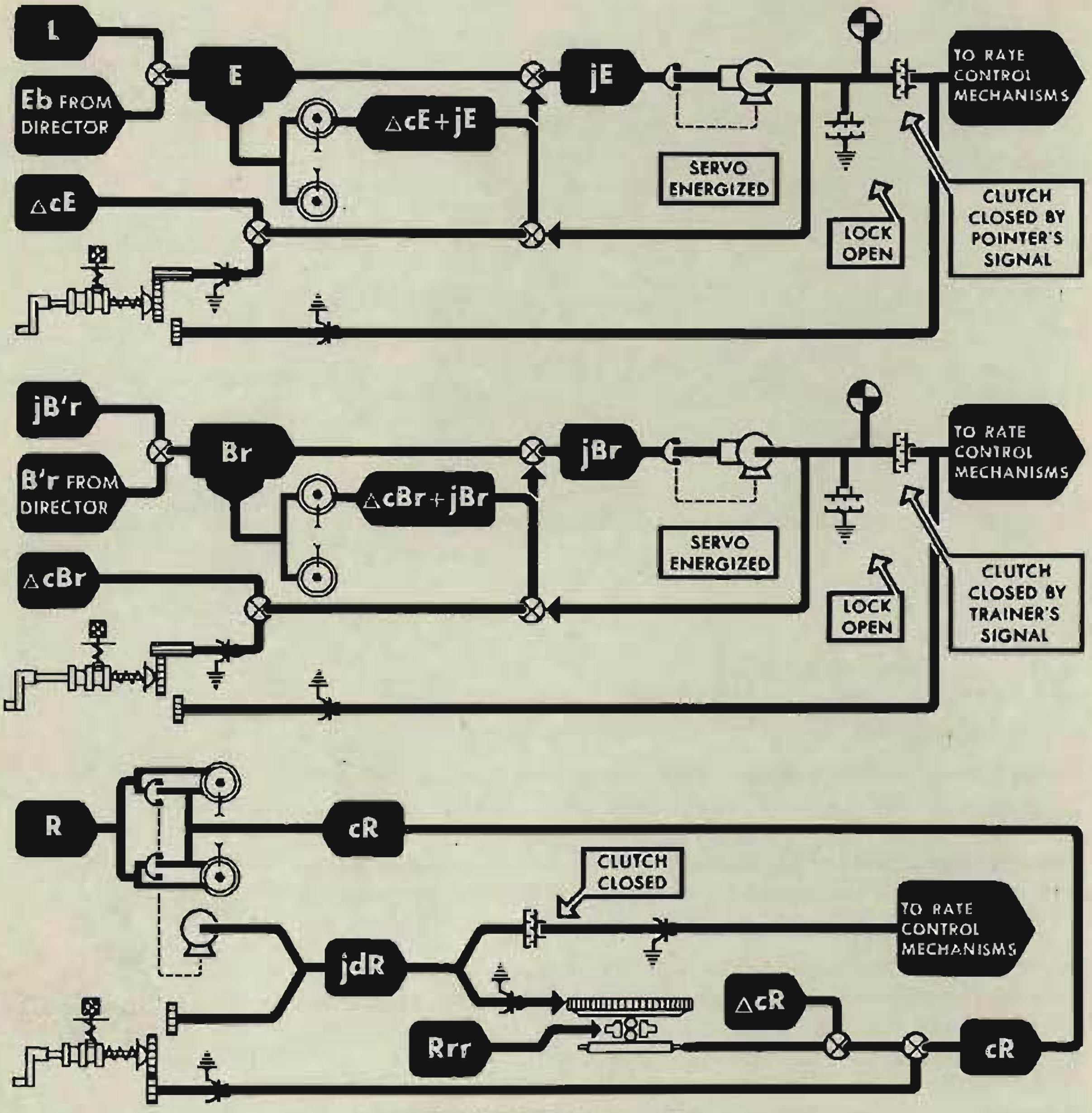
Set *A* at 90°.
At this new value of *A*, again increase and decrease generated range, generated elevation, and generated bearing in the manner described. The resulting changes in *dH, A* and *Sh* should correspond to the changes indicated on the test form.

Change elevation to 80°.
Set *A* at 180°, and 270°.
At each of these values of *A*, increase and decrease generated range, generated elevation, and generated bearing in the manner described. The resulting changes will be different from the changes in the tests in which *E* was set at 0°. Also, with *E* at 0°, only one value changes at a time; with *E* at 80°, other values, as well as those listed, may drive off slightly.

No specific change in target angle is given.
To check the changes in *A*, use the following setup:
Set *A* at 90° and *E* at 0°.
Set *Sh* at 200 knots.
Slowly increase *cR* 450 yards, with the manual push-button depressed.
A should increase about 22°.
Slowly decrease *cR* 450 yards.
A should decrease about 22°.

AUTOMATIC RATE CONTROL

An automatic rate control test should be run to check the *jE* and the *jBr* locks, clutches, and motors, and the electrical connections between the director signal keys and the computer. Introduce the changes in generated range, elevation, and bearing at the director. Observe the changes in *A*, *Sh*, and *dH* at the computer.

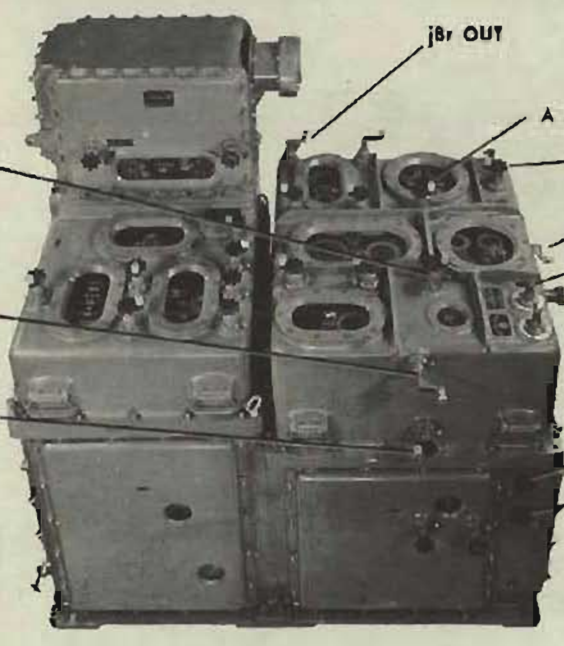


AUTOMATIC RATE CONTROL

Setting up the computer

1. Turn the power ON. Leave the time motor OFF.
2. Turn the control switch to AUTO.
3. Turn the range rate control switch to AUTO.
4. Position the range rate ratio knob at 2.
5. Set *L* and *Zd* at 2000′.
6. Lock the generated range, elevation, and bearing cranks in the OUT position.
7. Lock the *dH* handcrank OUT.
8. Set the *Sh* and *A* handcranks in AUTO.
9. Set the *Co* handcrank IN.

10 Set the fire control switchboard to receive director sight elevation, *Eb*, director train, *B'r*, and direct range, *R*, from the director.



Running the tests

Set *A* at 0° and set *Sh* at 200 or 300 knots, following the procedures outlined in the semi-automatic rate control tests.

Have the director pointer set director sight elevation, *Eb*, at 0°.

Read the *Sh* counter.

Have the director range finder operator *slowly increase* range 450 yards, with his signal key closed. *Sh* should decrease 88 (±5) knots.

Have the director range finder operator *slowly decrease* range 450 yards, with his signal key closed. *Sh* should increase 88 (±5) knots.

Read the *dH* dial.

Have the director pointer *slowly increase Eb* 2°00', with his signal key closed. *dH* should increase 88(±5) knots.

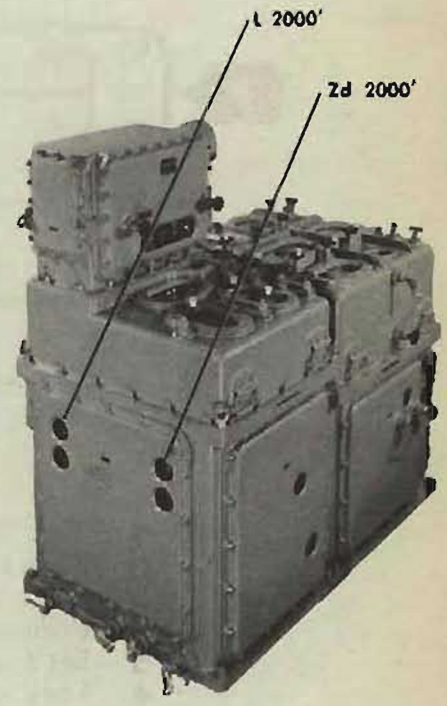
Have the director pointer *slowly decrease Eb* 2°00', with his signal key closed. *dH* should decrease 88(±5) knots.

Read the *A* dial.

Have the director trainer *slowly increase B'r* 2°00', with his signal key closed. *A* should increase.

Have the director trainer *slowly decrease B'r* 2°00', with his signal key closed. *A* should decrease.

If the results of the rate control tests are not satisfactory, consult the chapter on rate control test analysis.



TRANSMISSION TESTS

Transmission tests are among the most important checks of the fire control system. The miles of shipboard and instrument wiring and the hundreds of interconnecting switches require constant checking in order to locate a damaged wire, a partial ground, or a dirty contact before the circuit fails.

Transmission tests check each transmitter and each receiver for accuracy of transmission. Values which cover the range of travel of both the fine and coarse synchros are set on the transmitter and are read on the receiver. The complete test should be repeated for every possible switching combination throughout the ship.

But such a test would require several days of diligent work by experienced men. Instead of the complete transmission tests, three shorter checks may be used which will give the experienced man a good indication of the operation of most of the transmission circuits and receivers. These checks are the receiver synchronization test, the round robin test, and the overall test. If any of these special tests indicates faulty operation, the full transmission test should be run to check the particular circuit involved.

The RECEIVER SYNCHRONIZATION TEST measures the time a receiver takes to drive to synchronism from a specified offset. The offset is usually 180° of the coarse synchro rotor. With the circuit de-energized, the receiver is offset the specified amount, and then the circuit is energized. The rotors of the receiver synchros should snap to position, and the servo motor should drive the receiver to synchronism in the specified time. This specified time is that for a factory test of a new instrument and does not strictly apply to a shipboard test. After a little experience, however, the operator can judge whether the receiver drives to synchronism within a reasonable time period and with a normal number of overtravels.

The ROUND ROBIN TEST checks the tracking circuits. Changes of generated director train, generated director elevation, and generated range are transmitted to the director, which in turn transmits these values down to the computer. The observed dials on the computer should remain matched with the generated dials.

The OVERALL TRANSMISSION TEST is made by transmitting train and elevation from the director through the computer to the guns. The computer is set for zero prediction so that the gun orders are equal to the director values. In this way the transmission test of director elevation and director train is combined with that of gun elevation order and gun train order. The overall error is observed at the gun mounts. The experienced operator need check accuracy at one point only and then observe whether the guns follow smoothly from limit to limit in both directions as the director is driven slowly and smoothly from limit to limit.

Those circuits not covered by the above special tests should be checked by the standard transmission tests. Here again, the experienced operator may check for satisfactory operation without taking readings at every point specified in the table of values. Accuracy of alignment of the receiver with the transmitter may be determined at any single transmitted value. Whether the circuit is clear of opens, grounds, or dirty contact surfaces may be checked by observing the smoothness of operation of the receiver as the transmitter is turned slowly and smoothly between limits in both increasing and decreasing directions.

In the STAR SHELL COMPUTER MARK 1, MOD O, the gun order dials cannot be read without removal of the front cover. The Mod 1 and 2 instruments are equipped with a large window through which gun order values may be read so that transmission tests may be conducted in the same manner as for the Computer Mark 1. In order to eliminate the necessity for removing the front cover of the Mod O instrument, the transmission tests may be combined with the star shell A tests. Circuits are closed to transmit star shell gun orders to a gun mount, and the A test problem result values are read at the gun mount. If excessive errors occur, the front cover should be removed and the separate star shell transmission tests run.

SYNCHRONIZATION

When the Computer Mark 1 leaves the factory, all the receivers are adjusted to synchronize through a given travel in less than the maximum allowable N.I.O. time limit. The allowable time limit for a specified amount of travel varies for each receiver. These limits are arbitrarily established for a new computer undergoing N.I.O. acceptance tests at the factory.

SYNCHRONIZING TEST OF RECEIVERS

RECEIVER	DISPLACEMENT	MAXIMUM IN SECONDS
SHIP COURSE (Co)	180°	25
DIRECTOR TRAIN (B'r)	180°	15
DIRECTOR ELEVATION (Eb)	4800 MIN.	10
RANGE AUTOMATIC (R)	15000 YARDS	25
RANGE SPOT (Rj)	2000 YARDS	10
ELEVATION SPOT (Vj)	180 MILS	15
DEFLECTION SPOT (Dj)	180 MILS	15
SHIP SPEED (So)	16 KNOTS	5

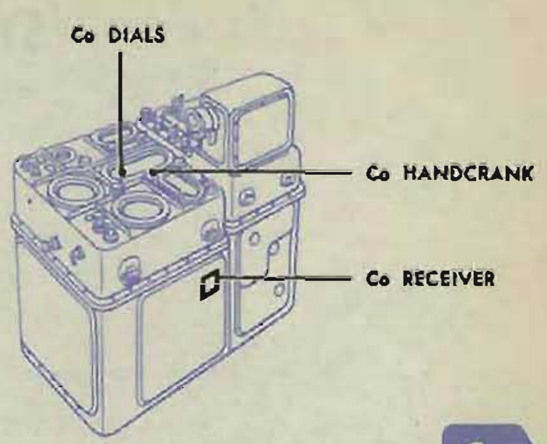
Timing receiver synchronization

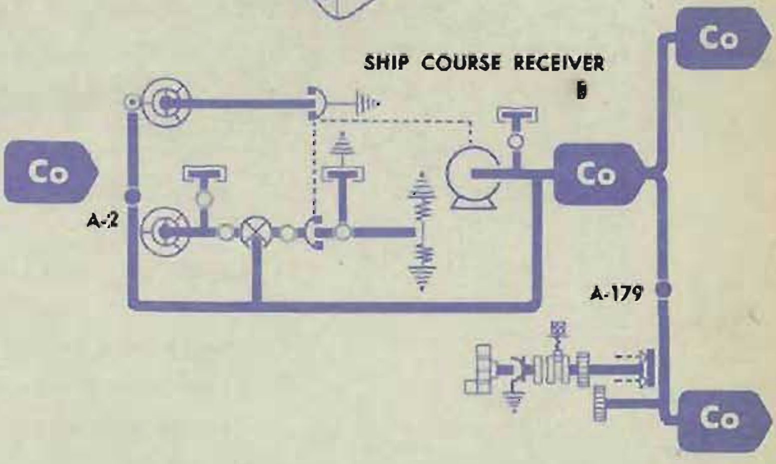
Make certain that the transmitted value is not changed during the checking of the synchronization time of a receiver.

The *B'r*, *Co*, *Vj*, *Dj*, and *Rj* receivers are timed through one half revolution of the rotor. To control the direction of rotation, it is necessary to offset the rotor somewhat less than one half revolution.

Timing the Co receiver

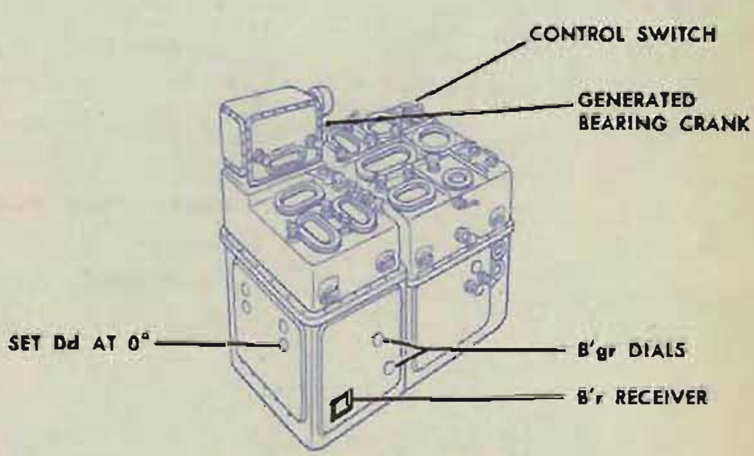
1. Set up the fire control switchboard to receive *Co* from the gyro compass.
2. At the computer, note the value of *Co*.
3. At the switchboard, open the *Co* receiver switch.
4. At the computer, put the *Co* handcrank IN and offset *Co* slightly less than 180°. Return the *Co* handcrank to the OUT position.
5. At the switchboard, close the *Co* receiver switch.
6. With a stop watch, measure the time from the instant the switch is closed to the instant the receiver synchronizes at its original value on the *Co* dial.
7. Repeat this procedure, offsetting *Co* slightly less than 180° in the other direction.

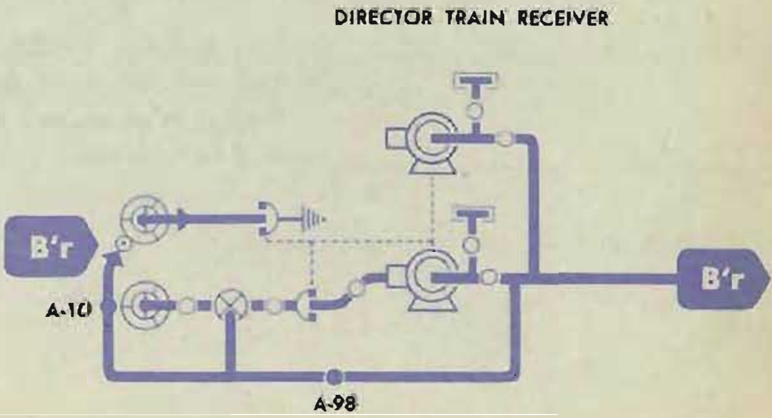


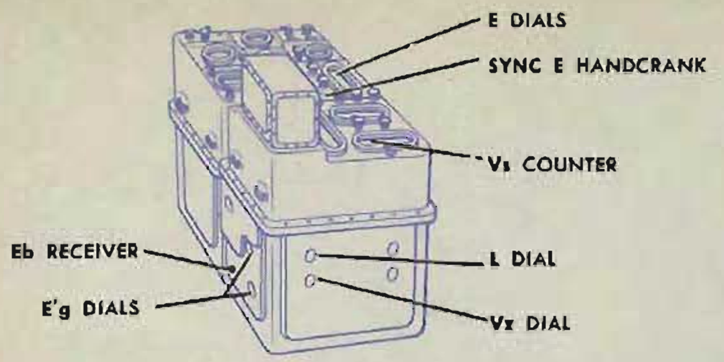


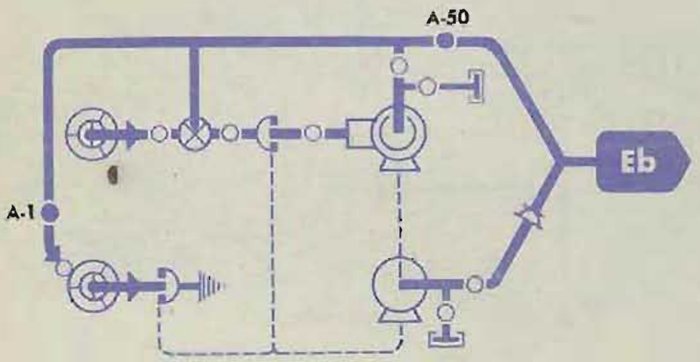
Timing the B'r receiver

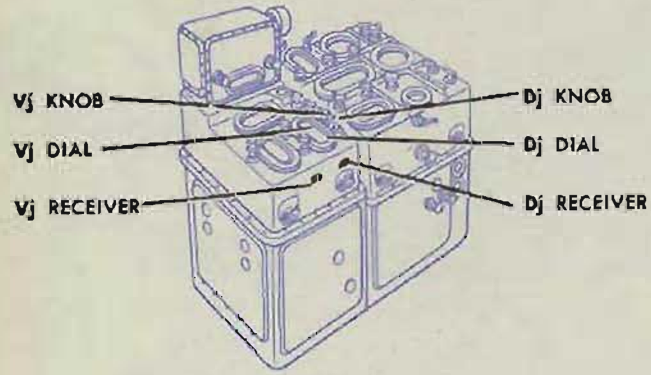
1. Set up the fire control switchboard to receive *B'r* from the director.
2. At the computer, turn the control switch to SEMI-AUTO.
3. Read the received value of *B'r* by setting *Dd* at 0° and reading *B'r* on the *B'gr* dials, or by reading *B'r* on the stable element dials.
4. At the switchboard, open the *B'r* receiver switch.
5. At the computer, turn the control switch to LOCAL. Use the generated bearing crank in the OUT position to offset *B'r* slightly less than 180°. Return the control switch to SEMI-AUTO.
6. At the switchboard, close the *B'r* receiver switch.
7. With a stop watch, measure the time from the instant the switch is closed to the instant the receiver synchronizes at its original value on the *B'gr* or stable element dials.
8. Repeat this procedure, offsetting *B'r* slightly less than 180° in the other direction.

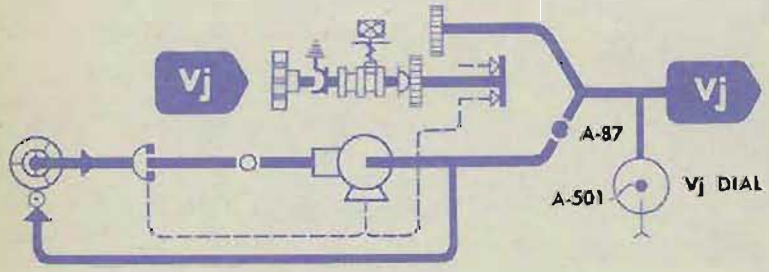


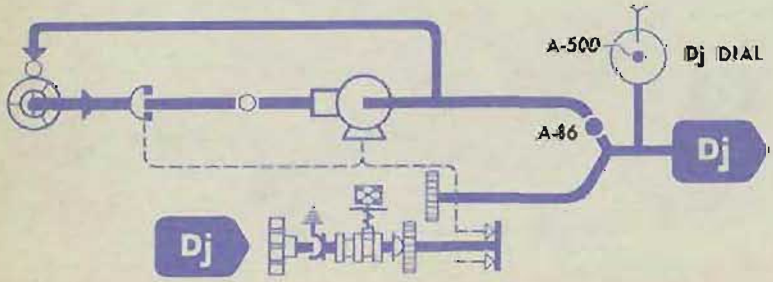












Timing the Eb receiver

1 Set L and Vs at 2000′ and Vz at 0′.
2 Set up the fire control switchboard to receive Eb from the director.
3 Transmit a 0° (or 2000′ on earlier machines) value of Eb from the director. Read the received value of Eb on the $E'g$ dials, or match the sync E dials and read Eb on the E dials. Check that the dials read 0° (2000′).
4 At the switchboard, open the Eb receiver switch.
5 At the director, increase Eb to 80° (6800′).
6 Close the Eb switch.
7 With a stop watch, measure the time from the instant the switch is closed to the instant the receiver is synchronized at 6800′ (80°).
8 Open the Eb switch.
9 At the director, decrease Eb to 0° (2000′).
10 Close the Eb switch, and measure the time until the receiver synchronizes at 0° (2000′).

Timing the Vj and Dj receivers

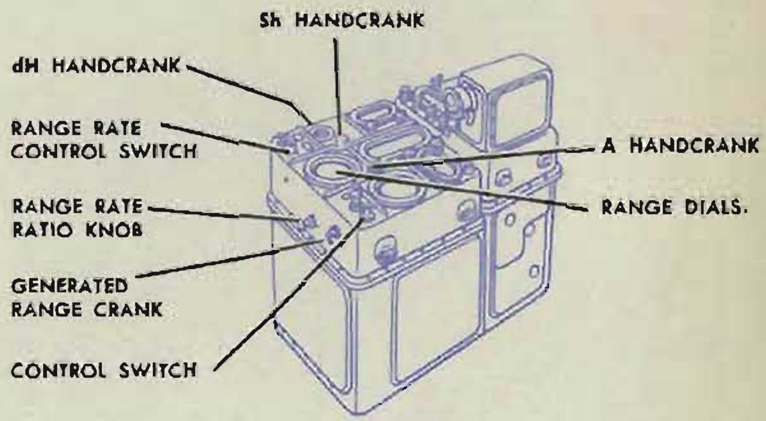
The procedure for checking these two receivers is the same except that different switches and knobs are used.

1 Set up the fire control switchboard to receive Vj (or Dj) from the director.
2 Transmit 0 mils Vj (or Dj) from the director. At the computer, check that the received value of Vj (or Dj) is 0 mils.
3 Open the Vj (or Dj) receiver switch at the switchboard.
4 Set Vj (or Dj) at slightly less than 180 DOWN (or LEFT), with the Vj (or Dj) knob in the IN position. Pull the knob OUT.
5 Close the Vj (or Dj) receiver switch.
6 With a stop watch, measure the time from the instant that the switch is closed to the instant that the receiver is again synchronized at 0 mils.
7 Repeat this procedure, offsetting Vj (or Dj) slightly less than 180 mils in the other direction.

Timing the range receiver

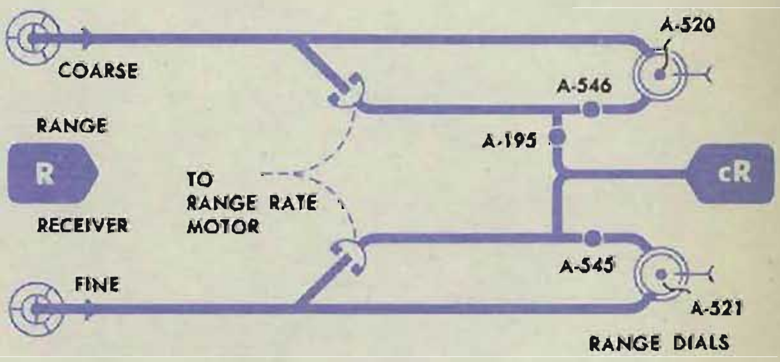
Preliminary setup

1 Set up the fire control switchboard to receive range from the director.
2 At the computer, set *E* at 25°.
3 Set the range rate ratio knob at 5.
4 Set the *A* and *Sh* handcranks at AUTO.
5 Pull the generated range crank and the *dH* handcrank OUT.
6 Turn the range rate control switch to AUTO.



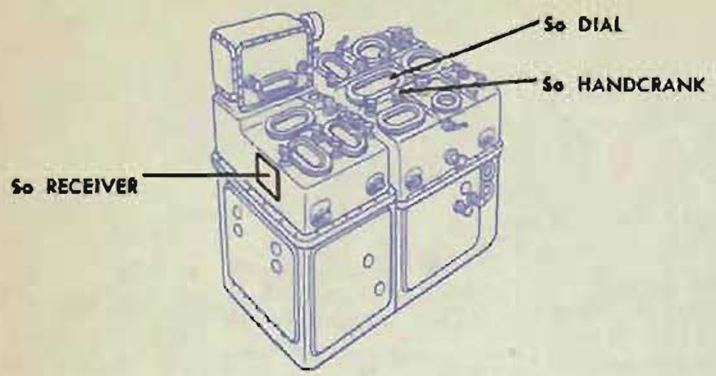
Increasing

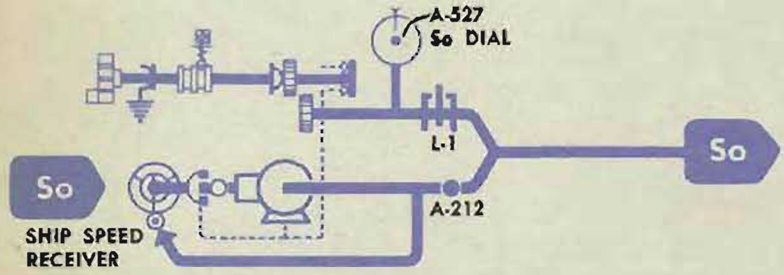
1 At the switchboard, open the range receiver switch.
2 At the computer, set *dH* at DIVE 250 knots and return the handcrank to the OUT position.
3 Set the range ring dials at 5000 yards.
4 Transmit 20,000 yards range from the director, keeping the range finder signal button depressed.
5 At the switchboard, close the range receiver switch.
6 With a stop watch, measure the time from the instant that the switch is closed to the instant that the receiver synchronizes at 20,000 yards on the range ring dials.



Decreasing

1 Open the range receiver switch.
2 Set *dH* at CLIMB 150 knots and return the handcrank to the OUT position.
3 Transmit 5000 yards range from the director, keeping the range finder signal button depressed.
4 At the switchboard, close the range receiver switch.
5 Measure the time from the instant that the switch is closed to the instant that the receiver synchronizes at 5000 yards.





Timing the So receiver

1 Set up the fire control switchboard to receive *So* from the pitometer log.

2 Note the value of *So* on the computer dial.

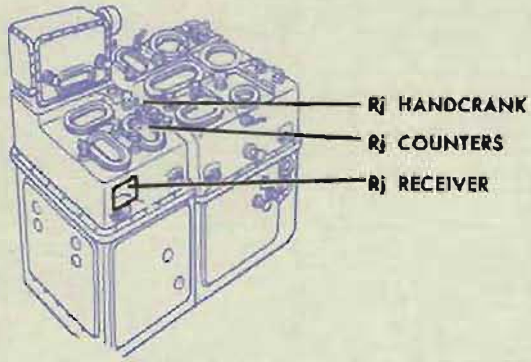
3 At the switchboard, open the *So* receiver switch.

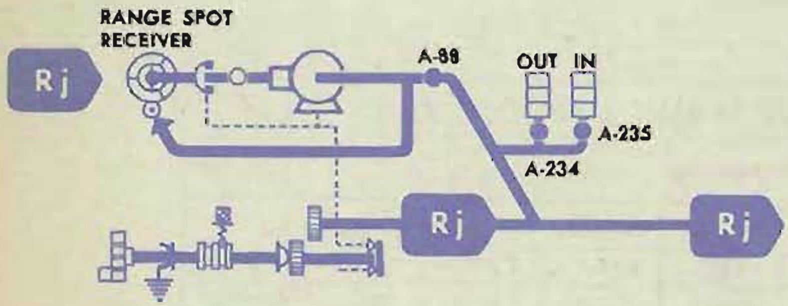
4 Push the *So* handcrank IN and offset *So* 16 knots. Pull the handcrank OUT.

5 Close the *So* switch.

6 With a stop watch, measure the time between the instant that the switch is closed and the instant that the receiver synchronizes, with the *So* dial at its original value.

7 Repeat this procedure, offsetting *So* 16 knots in the other direction if possible.





Timing the Rj receiver

1 Set up the fire control switchboard to receive *Rj* from the director.

2 At the director, set *Rj* at IN 1000 yards. At the computer, check that the *Rj* counter reads IN 1000 yards.

3 At the switchboard, open the *Rj* receiver switch.

4 Push the *Rj* handcrank IN, offset *Rj* slightly less than 2000 yards, and pull the *Rj* handcrank OUT.

5 Close the *Rj* receiver switch.

6 Measure the time between the instant that the switch is closed and the instant that the receiver synchronizes at 1000 yards IN on the *Rj* counter.

7 Repeat this procedure, offsetting *Rj* slightly less than 2000 yards in the other direction.

TRANSMISSION TESTS

These transmission tests are made according to the information given in NAVORD Form 1229, Transmission Tests. Each one tests a single transmitter or receiver. For each test the allowable limits of error are given in NAVORD Form 1229.

ALL READINGS ARE TO BE CHECKED FOR INCREASING AND DECREASING SETTINGS

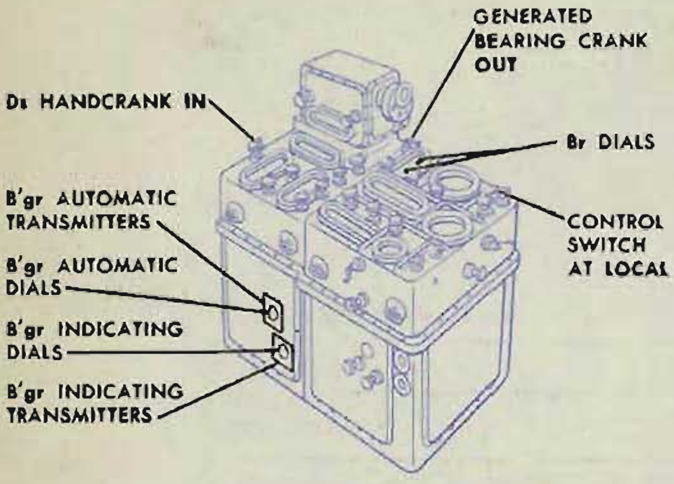
COMPUTER MARK I							MAX. ALLOW. ERROR
QUANTITY	CHECK POINTS						
GUN TRAIN (I)	59°	118°	177°	236°	295°	354°	2 MIN.
GUN TRAIN (A)	59°	118°	177°	236°	295°	354°	2 MIN.
GUN ELEV. (I)	1200'	1850'	3200'	4550'	5900'	7000'	2 MIN.
GUN ELEV. (A)	1200'	1850'	3200'	4550'	5900'	7000'	2 MIN.
TRAIN PARALLAX	R 10° 50'	R 5° 50'	R 0° 50'	L 0° 50'	L 5° 50'	L 10° 50'	2 MIN.
ELEV. PARALLAX	U 3° 30'	U 2° 50'	U 0° 50'	D 0° 50'	D 2° 50'	D 3° 30'	2 MIN.
FUZE SETTING	2.00	9.00	18.00	27.00	36.00	44.00	.01 SEC.
SIGHT ANGLE	2100'	2360'	2720'	3080'	3440'	3700'	3 MIN.
SIGHT DEFLECTION	330	400	470	540	610	670	1.0 MIL.
RANGE (A)	1500	4800	11400	14700	17900	20000	45 YDS.
RANGE CORR.	100	200	400	600	800	1000	30 YDS.
BEARING CORR. (I)	2°	4°	6°	8°	10°		2 MIN.
BEARING CORR. (A)	1°	2°	3°	4°	5°		2 MIN.
ELEV. CORR. (I)	2°	4°	6°	8°	10°		2 MIN.
ELEV. CORR. (A)	1°	2°	3°	4°	5°		2 MIN.
TARGET COURSE	60°	120°	180°	240°	300°	360°	2.0 DEG.
DIRECTOR TRAIN	59°	118°	177°	236°	295°	354°	6 MIN.
DIRECTOR ELEVATION	1200'	1850'	3200'	4550'	5900'	7000'	6 MIN.
RANGE SPOT	IN 1700	IN 1100	IN 60	OUT 60	OUT 1100	OUT 1700	30 YDS.
ELEV. SPOT	U 170	U 115	U 55	D 55	D 115	D 170	3.0 MIL.
DEFL. SPOT	R 170	R 115	R 55	L 55	L 115	L 170	3.0 MIL.
* SHIP SPEED	10	15	20	25	30	40	0.6 KN.
* SHIP COURSE	59°	118°	177°	236°	295°	354°	6 MIN.

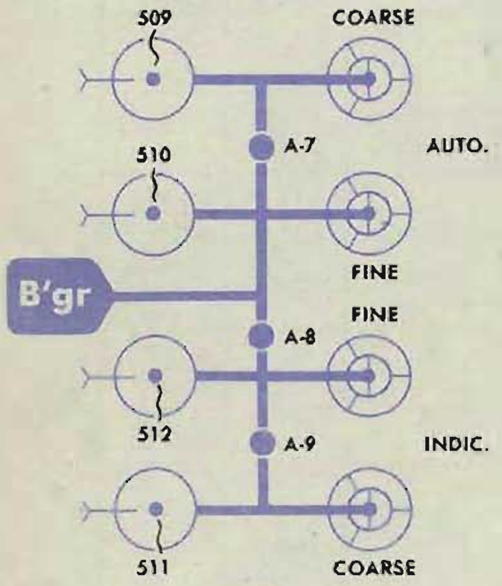
* THESE CHECK POINTS ARE GIVEN FOR SHOP TESTS WITH DUMMY TRANSMITTERS
NOTE: (I) = INDICATING (A) = AUTOMATIC

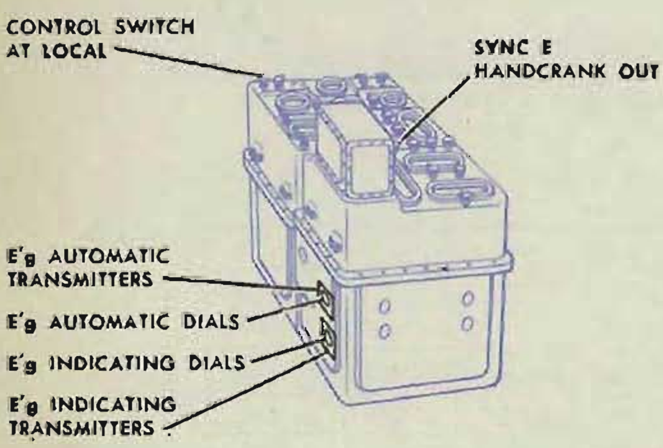
STAR SHELL COMPUTER MARK I MODS. 0, I							MAX. ALLOW. ERROR
QUANTITY	CHECK POINTS						
S. S. RANGE SPOT	IN 1500	IN 900	IN 300	OUT 300	OUT 900	OUT 1500	50 YDS.
S. S. GUN TRAIN +	59°	118°	177°	236°	295°	354°	5 MIN.
S. S. GUN ELEVATION +	1200	2000	2900	4000	4500	5200	5 MIN.
S. S. FUZE SETTING	9.00	15.30	21.60	27.90	34.20	40.50	0.01 SEC.

NOTE: + HOLD S. S. DEFLECTION AND ELEVATION SPOTS ON ZERO FOR THESE TESTS

RUNNING TRANSMISSION TESTS







Checking B'gr indicating transmission

1. Set up the fire control switchboard to transmit *B'gr* indicating (No. 1) to each gun mount.
2. At the gun mounts, set each gun on exactly 59°. Shift control to MANUAL.
3. At the computer, turn the control switch to LOCAL.
4. Set the *Br* dials at 59°, with the generated bearing crank in the OUT position. Use the *Ds* handcrank in the IN position to set the *B'gr* indicating dials at 59°, from the increasing and decreasing directions.
5. At the gun mounts, read the error on the follow-the-pointer dials for each direction of transmitter setting.
6. Continue the test in the same manner with *B'gr* at 118°, 177°, 236°, 295°, and 354°.

Checking B'gr auto transmission

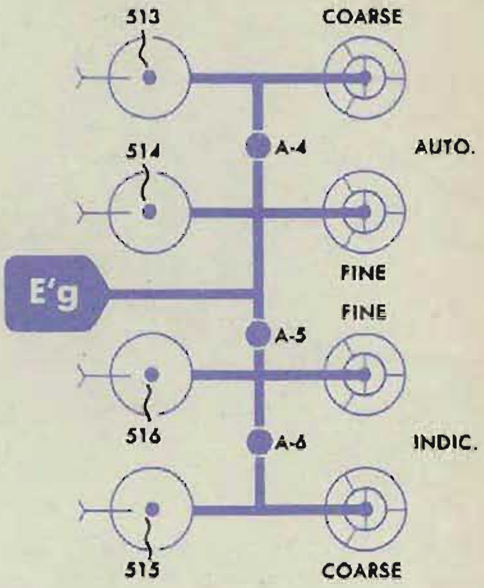
1. Set up the fire control switchboard to transmit *B'gr* automatic (No. 2) to each gun mount.
2. At the gun mounts, put the guns in AUTO control.
3. Run the balance of the test in the same manner as the *B'gr* indicating transmission test, but read the error on the train dials at the guns.

Checking E'g indicating transmission

1. Set up the fire control switchboard to transmit *E'g* indicating (No. 1) to each gun mount.
2. At the gun mounts, set gun elevation at exactly 1200'. Shift control to MANUAL.
3. At the computer, turn the control switch to LOCAL. Use the sync *E* handcrank in the OUT position to set the *E'g* indicating dials at 1200', from the increasing and decreasing directions.
4. Read the transmission error at each gun mount on the follow-the-pointer dials for each direction of transmitter setting.
5. Continue the test in the same manner with *E'g* at 1850', 3200', 4550', 5900', and 7000'.

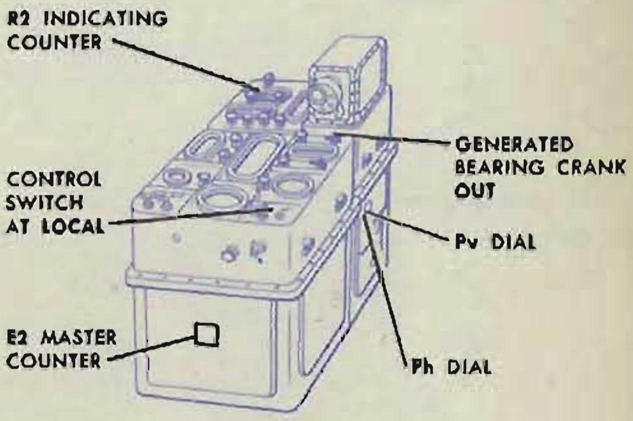
Checking E'g auto transmission

1 Set up the fire control switchboard to transmit *E'g* automatic (No. 2) to each gun mount.
2 At the gun mounts, put each gun in AUTO control.
3 Run the balance of the test in the same manner as the *E'g* indicating transmission test, but read the errors on the elevation dials at the guns.



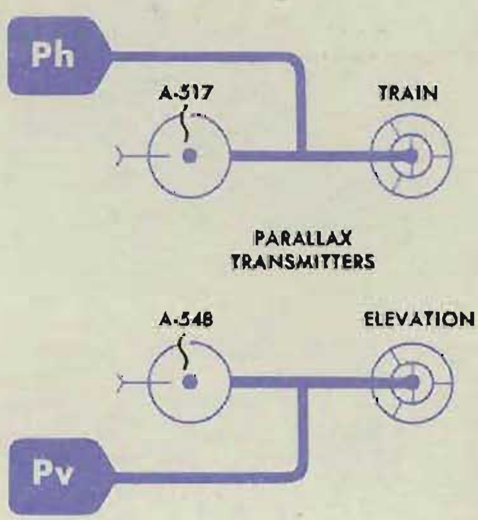
Checking Ph transmission

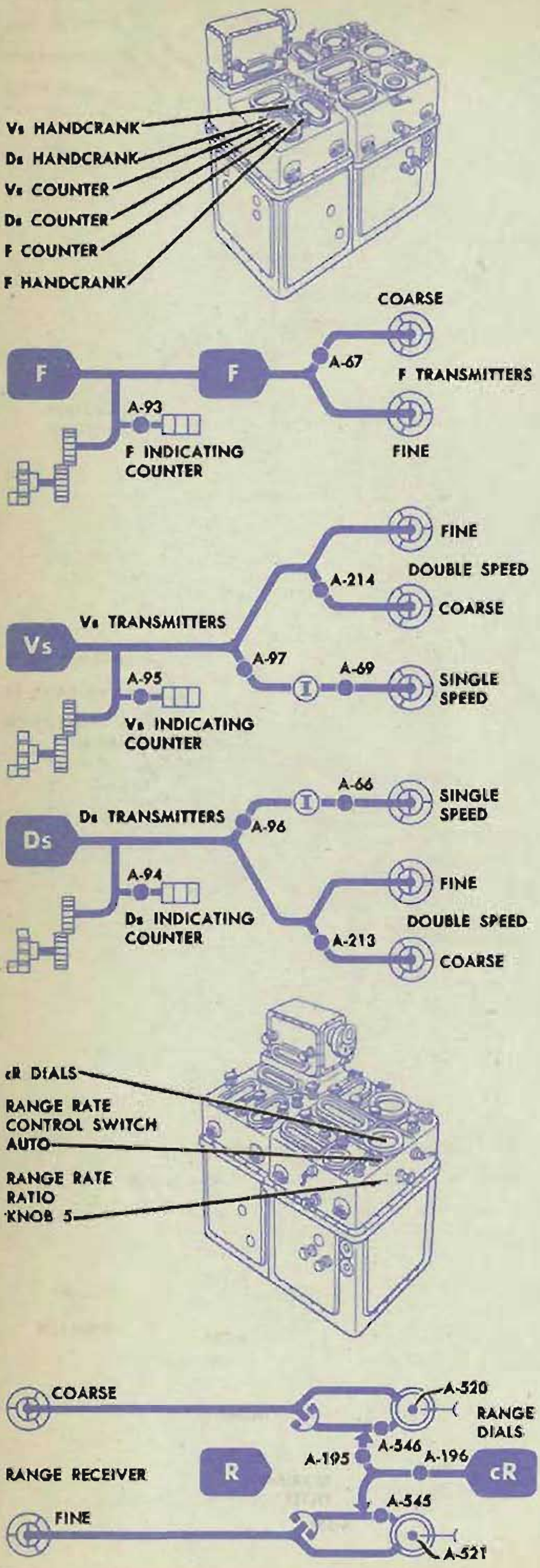
1 Set up the fire control switchboard to transmit *Ph* to each gun mount.
2 At the computer, turn the control switch to LOCAL.
3 Set *R2* at a low value and *E2* at a high value.
4 Use the generated bearing crank in the OUT position to set the *Ph* dial at RIGHT 10°50′, from the increasing and decreasing directions.
5 At the gun mounts, read the received value on the train parallax ring dial for each direction of dial setting.
6 Continue the test in the same manner with *Ph* at RIGHT 5°50′, RIGHT 0°50′, LEFT 0°50′, LEFT 5°50′, and LEFT 10°50′.



Checking Pv transmission

1 Set up the fire control switchboard to transmit *Pv* to each gun mount.
2 At the computer, turn the control switch to LOCAL.
3 Set *R2* at a low value and *E2* at a high value.
4 Use the generated bearing crank in the OUT position to set the *Pv* dial at UP 3°30′, from both the increasing and decreasing directions.
5 At the gun mounts, read the value transmitted to each gun mount on the elevaion parallax ring dial, if the mount receives *Pv*.
6 Continue the test in the same manner with *Pv* at UP 2°50′, UP 0°50′, DOWN 0°50′, DOWN 2°50′, DOWN 3°30′.





Checking F transmission

1. Set up the fire control switchboard to transmit *F* to each gun mount.
2. At the computer, set the *F* counter at 2.00 seconds from the increasing and decreasing directions with the fuze handcrank IN.
3. At the gun mounts, read the received value on the fuze setting indicator regulator for each setting.
4. Continue the test in the same manner with *F* at 9.00, 18.00, 27.00, 36.00, and 44.00 seconds.

Checking Vs transmission

1. Set up the fire control switchboard to transmit *Vs* to each gun mount.
2. At the computer, set the *Vs* counter at 2100′ from the increasing and decreasing directions with the *Vs* handcrank IN.
3. At the gun mounts, read the received value on the sight angle dials for each setting.
4. Continue the test in the same manner with *Vs* at 2360′, 2720′, 3080′, 3440′, and 3700′.

Checking Ds transmission

1. Set up the fire control switchboard to transmit *Ds* to each gun mount.
2. At the computer, set the *Ds* counter on 330 mils from the increasing and decreasing directions with the *Ds* handcrank IN.
3. At the gun mounts, read the received value on the sight deflection dials for each setting.
4. Continue the test in the same way with *Ds* at 400, 470, 540, 610, and 670 mils.

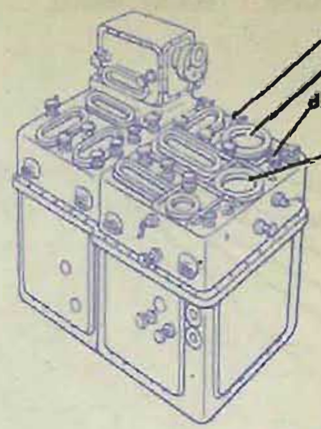
Checking the range receiver

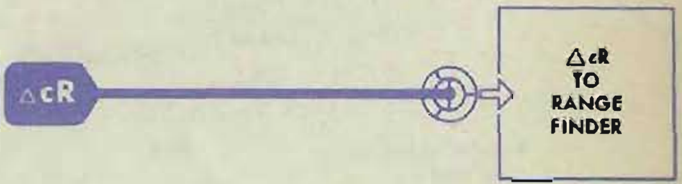
1. Set up the fire control switchboard to receive range from the director.
2. At the computer, turn the range rate control switch to AUTO, and set the range rate ratio knob at 5.
3. At the director, transmit 1500 yards range. The range finder operator should set this value exactly at 1500 yards from both the increasing and decreasing directions. The signal key should be kept closed to keep the range receiver synchronized while the setting is made.
4. At the computer, read the received value on the *cR* dials for each transmitter setting.
5. Continue the test by transmitting range values of 4800, 11,400, 14,700, 17,900, and 20,000 yards from the director.

Gene Slover's US Navy Pages | Table of Contents

Checking ΔcR transmission

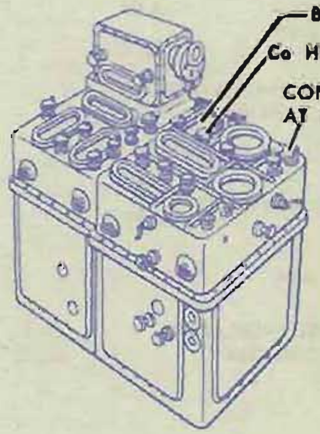
1 Set up the fire control switchboard to transmit ΔcR to the director.
2 At the director, turn the change of range receiver ON. Set the range dials at some even value within the limits of the 200-yard graduations.
3 At the computer, set cR equal to the director setting. Set dR at some negative value on the inscribed side of the dial.
4 Turn the time line until cR decreases 200 yards.
5 At the director, read the change on the director range dials.
6 Repeat steps 4 and 5 four times (total change, 1000 yards).
7 Set dR at some positive value and repeat the test.





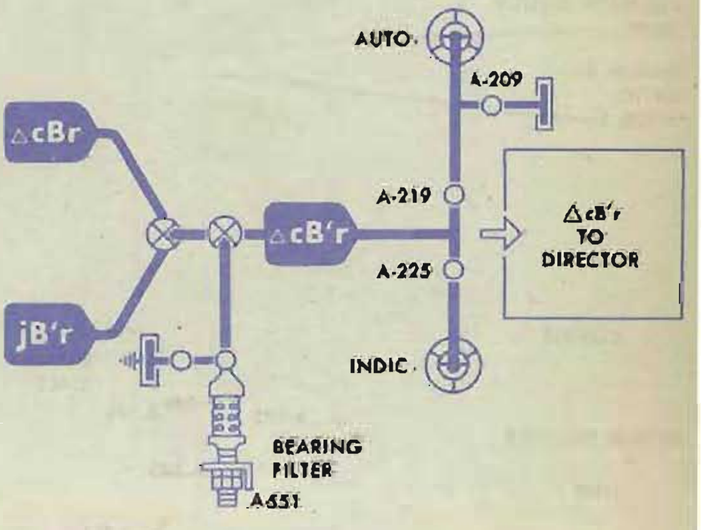
Checking $\Delta cB'r$ indicating transmission

1 Set up the fire control switchboard to transmit $\Delta cB'r$ to the director.
2 At the computer, turn the control switch to LOCAL. Use the Co handcrank in the IN position to set the bearing dials at some even value.
3 At the director, set the selector lever in AUTO. Match the train indicating dial at the index.
4 At the computer, turn the Co handcrank slowly to increase bearing 2°.
5 At the director, check that the train indicating dial remains matched at the index.
6 Repeat steps 4 and 5 four times (total change, 10°).
7 Repeat the test in the decreasing direction.

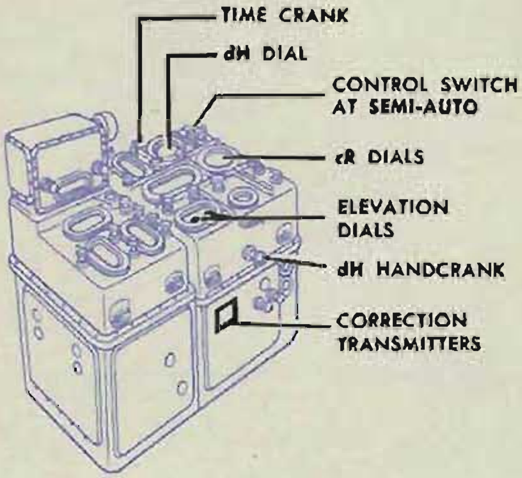


Checking $\Delta cB'r$ auto transmission

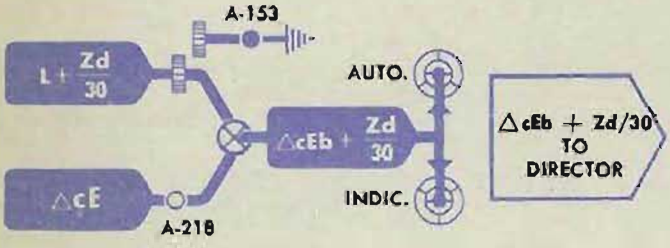
1 Set up the fire control switchboard to transmit $\Delta cB'r$ to the director.
2 At the computer, turn the control switch to LOCAL. Use the Co handcrank in the IN position to set the bearing dials on an even value.
3 At the director, set the selector lever in AUTO. Set the train dials at some even value.
4 At the computer, turn the Co handcrank slowly to increase bearing 1°.
5 Check that the director dials increase 1°.
6 Repeat steps 4 and 5 four times (total change, 5°).
7 Repeat the test in the decreasing direction.



Checking $\triangle cEb + Zd/30$ indicating transmission



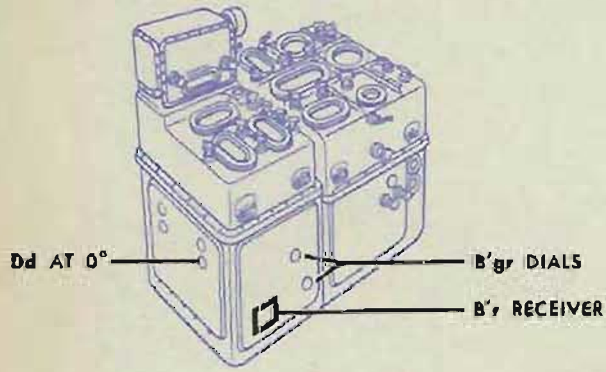
1. Set up the fire control switchboard to transmit $\triangle cEb + Zd/30$ to the director.
2. At the director, set the selector lever in AUTO. Match the elevation indicating dial at the index.
3. At the computer, turn the control switch to SEMI-AUTO. Set *cR* at 1500 yards. Set *dH* at CLIMB 150.
4. Turn the time crank until *cE* increases 2°.
5. At the director, check that the elevation indicating dial remains matched.
6. Repeat steps 4 and 5 four times (total change, 10°).
7. Set *dH* at DIVE 150 and repeat the test.



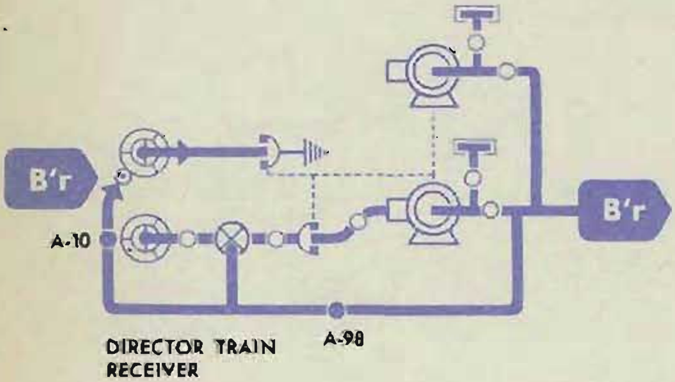
Checking $\triangle cEb + Zd/30$ auto transmission

1. Set up the fire control switchboard to transmit $\triangle cEb + Zd/30$ to the director.
2. At the director, set the selector lever in AUTO. Set the director elevation dials at some even value.
3. At the computer, turn the control switch to SEMI-AUTO. Set *cR* at 1500 yards. Set *dH* at CLIMB 150.
4. Turn the time crank until *cE* increases 1°.
5. At the director, check that the elevation dial increases 1°.
6. Repeat steps 4 and 5 four times (total change 5°).
7. Set *dH* at DIVE 150 and repeat the test.

Checking the B'r receiver

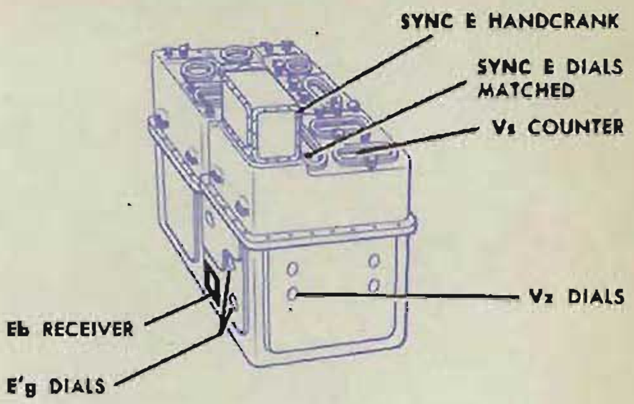


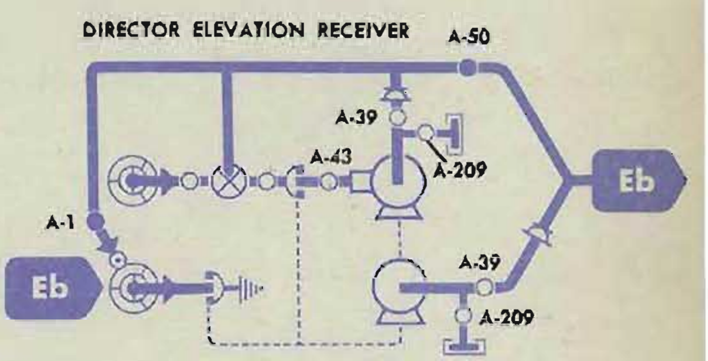
1. Set up the fire control switchboard to receive *B'r* from the director.
2. At the computer, set *Dd* on 0.
3. At the director, transmit a *B'r* value of 59°. The trainer should set this value on exactly 59° from both the increasing and decreasing directions.
4. At the computer, read the received value of *B'r* on the *B'gr* dials, for each transmitter setting.
5. Continue the test by transmitting *B'r* values of 118°, 177°, 236°, 295°, and 354°.



Checking the Eb receiver

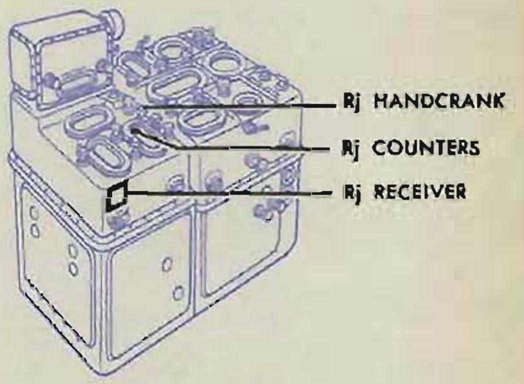
1 Set up the fire control switchboard to receive *Eb* from the director.
2 At the computer, set *Vs* at 2000′, *Vz* at 0, and match the sync *E* dials at the index.
3 At the director, transmit a value of −13°20′ (1200′) of *Eb*. The pointer should set the value on exactly −13°20′ from the increasing and decreasing directions.
4 At the computer, read the value of *Eb* received on the *E′g* dials for each setting.
5 Continue the test by transmitting *Eb* values of 1850′, 3200′, 4550′, 5900′, and 7000′.

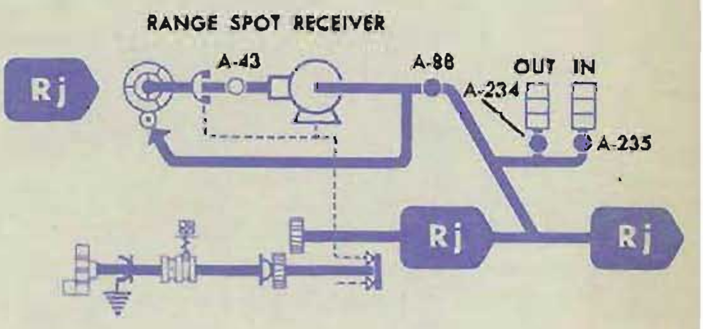


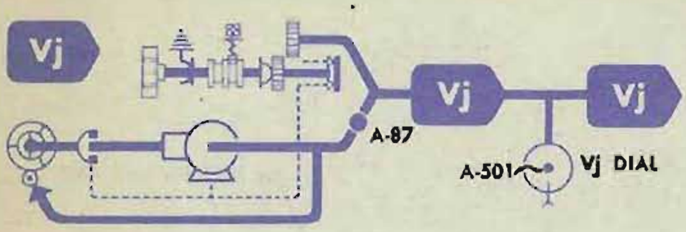


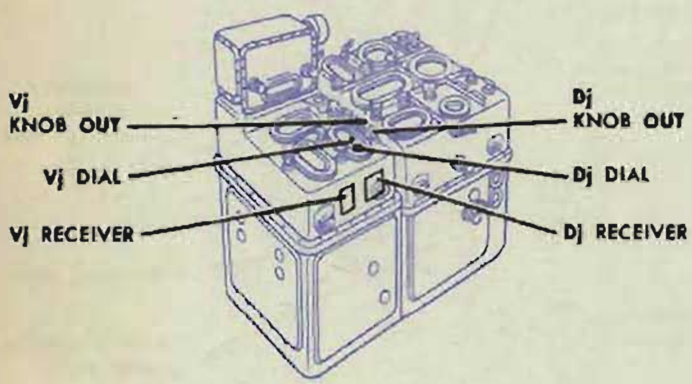
Checking the Rj receiver

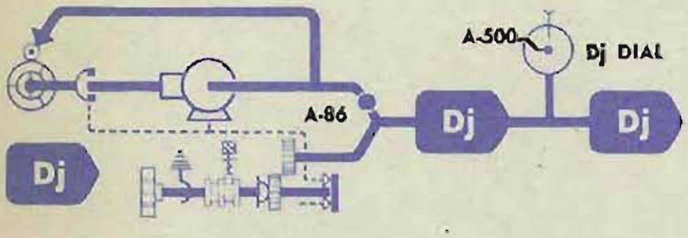
1 Set up the fire control switchboard to receive range spot from the director.
2 At the computer, pull the *Rj* knob out.
3 At the director, transmit an *Rj* value of IN 1700 yards from the increasing and decreasing directions.
4 At the computer, read the value received on the *Rj* counter for each direction of setting.
5 Continue the test by transmitting *Rj* values of IN 1100, IN 60, OUT 60, OUT 1100, and OUT 1700 yards.

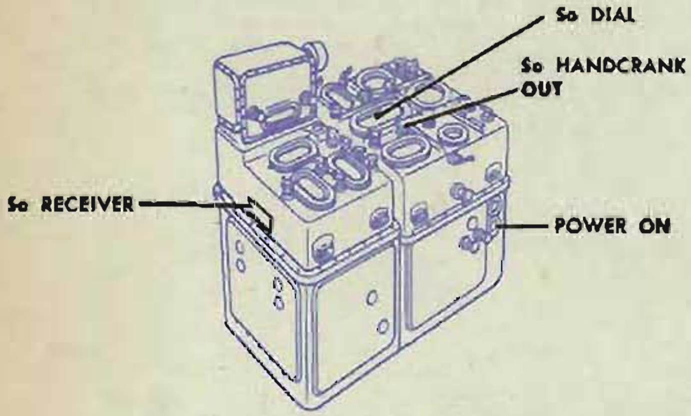


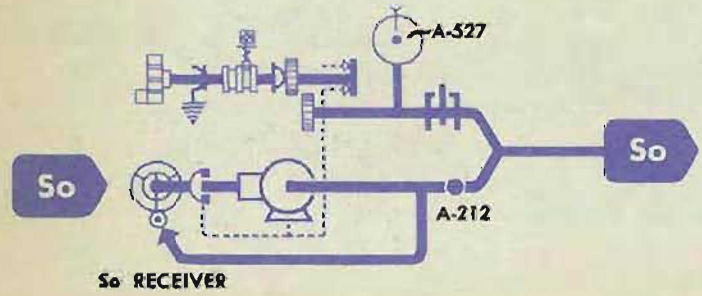












Checking the Vj receiver

1. Set up the fire-control switchboard to receive elevation spot from the director.
2. At the computer, pull the *Vj* knob out.
3. At the director, transmit a *Vj* value of UP 170, from the increasing and decreasing directions.
4. At the computer, read the value on the *Vj* dial for each direction of setting.
5. Continue the test by transmitting *Vj* values of UP 115, UP 55, DOWN 55, DOWN 115, and DOWN 170 mils.

Checking the Dj receiver

1. Set up the fire-control switchboard to receive deflection spot from the director.
2. At the computer, pull the *Dj* knob out.
3. At the director, transmit a *Dj* value of RIGHT 170, from the increasing and decreasing directions.
4. At the computer read the value on the *Dj* dial for each direction of setting.
5. Continue the test by transmitting *Dj* values of RIGHT 115, RIGHT 55, LEFT 55, LEFT 115, and LEFT 170 mils.

Checking the So receiver

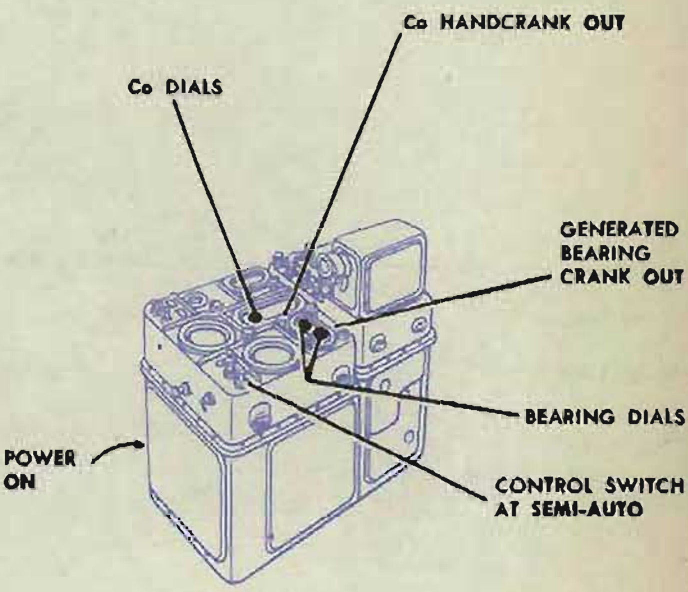
It is not practical to run the complete transmission test of the *So* receiver in the normal shipboard setup because of the difficulty in varying the transmitted values of *So*. An approximate check of receiver operation can be made by comparing the value on the computer *So* dial with the pitometer log reading at any given time during normal automatic operation of the *So* receiver. The readings should not differ more than 0.6 knots.

To run the complete transmission test:

1. Connect a dummy transmitter to the *So* circuit in the computer.
2. Pull the *So* handcrank OUT; turn the power switch ON.
3. Transmit a value of 10 knots from the dummy. Set the value from the increasing and decreasing directions.
4. At the computer, read the received value on the *So* dial for each direction of setting.
5. Continue the test by transmitting *So* values of 15, 20, 25, 30, and 40 knots.

Checking the Co receiver

It is not practical to run the complete transmission test of the *Co* receiver in the normal shipboard setup because of the difficulty in varying the transmitted value of *Co*. An approximate check of receiver operation can be made by comparing the value of *Co* read on the computer dials with the master compass reading at any given time during normal automatic operation of the *Co* receiver.



To run the complete transmission test:

1. Connect dummy transmitters to the *Co* and *B'r* circuits in the computer.

2. Transmit 0° *B'r* to the computer, and energize the *B'r* receiver.

3. Pull the *Co* handcrank OUT, and turn the power switch ON. Turn the control switch to SEMI-AUTO. Set *So* and *Sh* on 0 knots. Set *L* and *Zd* on 2000'.

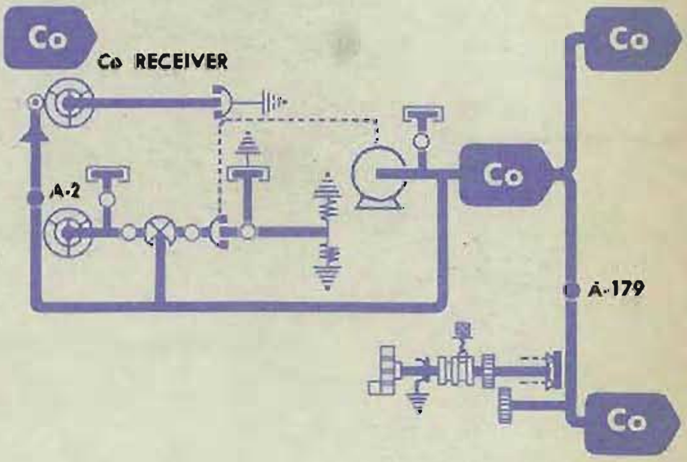
4. Transmit 0° *Co* to the computer. Check that the computer ship and compass ring dials read a 0° value of *Co*.

5. Match one index of the fine generated bearing dial to the zero index of the fine ring dial with the generated bearing crank in the OUT position.

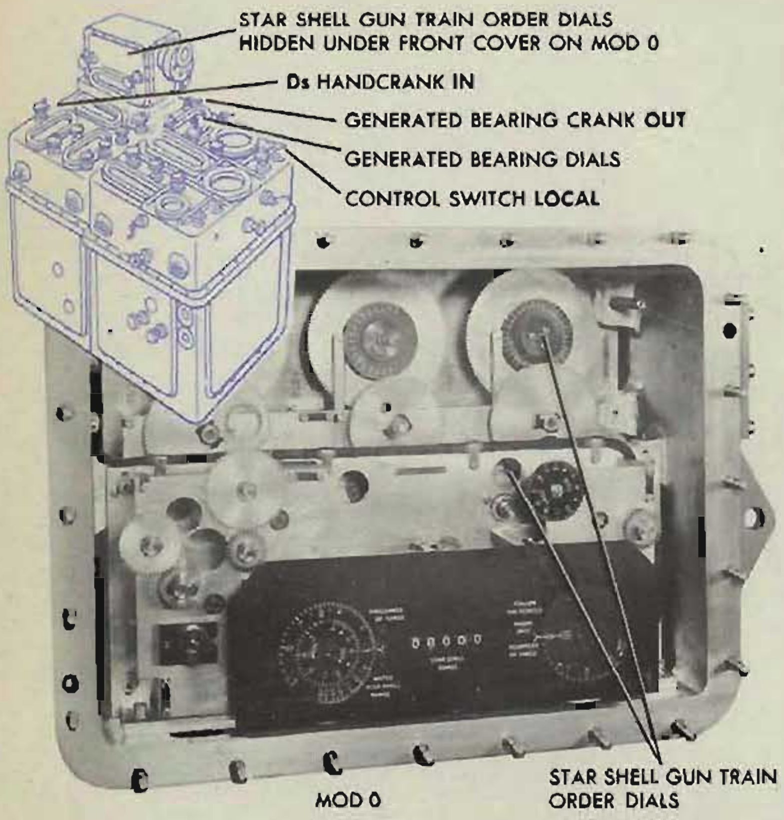
6. Set the *Co* transmitter on 0° from both the increasing and decreasing directions.

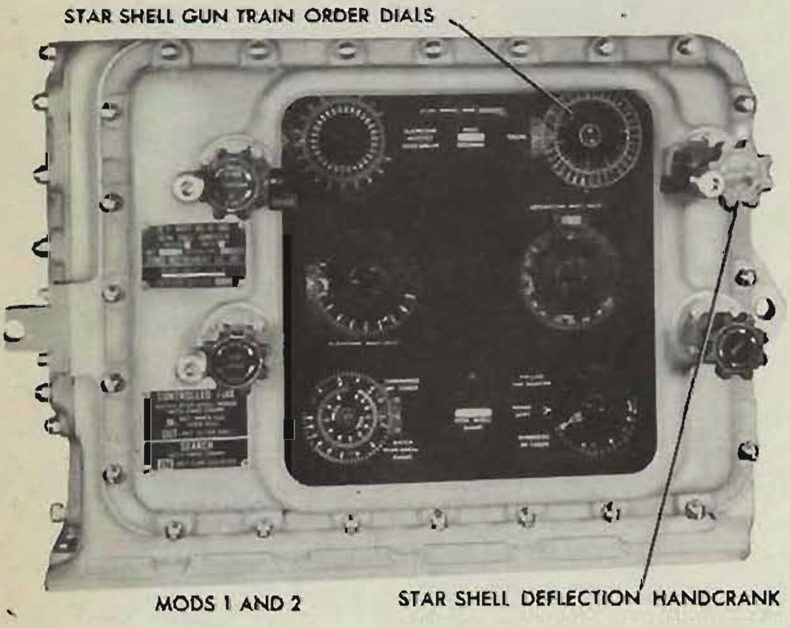
7. Use the generated bearing crank to adjust the fine generated bearing dial index initially so that the lost motion is evenly distributed on each side of the zero index of the fine ring dial, for each direction of transmitter setting.

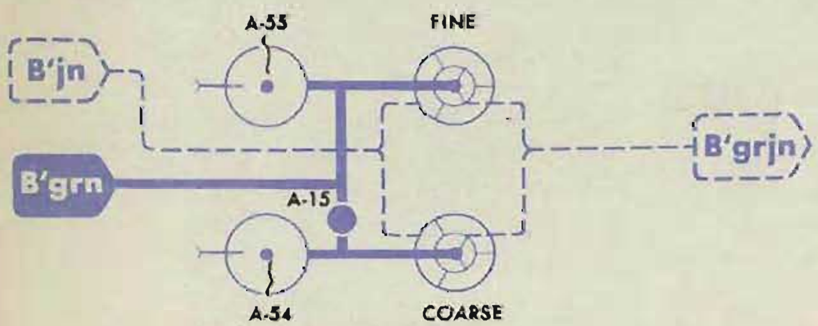
8. Continue the test, without disturbing the generated bearing setup, for *Co* values of 59°, 118°, 177°, 236°, 295°, and 354°. Read the computer ship dial against the compass ring dial for coarse values. Read the selected index of the fine generated bearing dial against the ring dial for fine values.



STAR SHELL TRANSMISSION TESTS







An approximate transmission test for the Star Shell Computer Mod 0 can be made by setting up a star shell A test problem and reading the transmitted orders at the gun mounts. For a more accurate transmission test, the front cover of the star shell computer should be removed and the transmitter dials set at the given values. On mods 1 and 2 these dials can be read without removing the cover.

Checking B'grjn transmission

1. Set up the fire control switchboard to transmit star shell gun train order to each gun mount.
2. At the director, set star shell deflection spot on 0.
3. At the gun mounts, put the guns in AUTO control.
4. At the computer,

   for mod 0:

   Turn the control switch to LOCAL.
   Set the bearing dials on 59°, with the generated bearing crank in the OUT position.
   Use the *Ds* handcrank in the IN position to set the star shell gun train order dials on the exact value of 59° from both the increasing and decreasing directions.

   for mods 1 and 2:

   Put the star shell deflection handcrank in the SEARCH position, and set the star shell gun train order dials on 59°, from both the increasing and decreasing directions.
5. At the gun mounts, read the received value on the train dials for each direction of transmitter setting.
6. Continue the test in the same manner for *B'grjn* values of 118°, 177°, 236°, 295°, and 354°.

Checking E'gjn transmission

1 Set up the fire control switchboard to transmit star shell gun elevation order to each gun mount.

2 At the director, set star shell elevation spot on 0.

3 At the gun mounts, put the guns in AUTO control.

4 At the computer,

for mod 0:

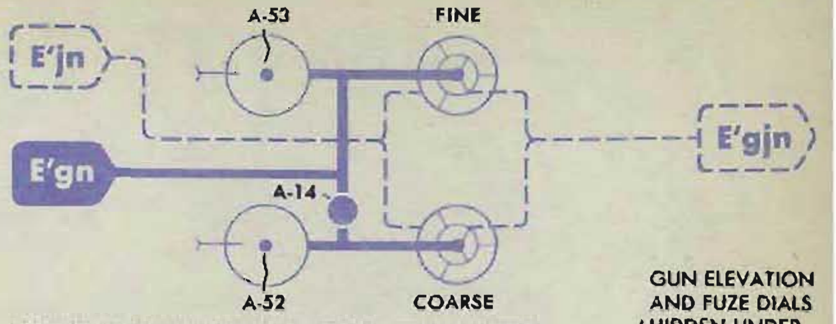
Use the sync *E* handcrank in the OUT position to set the star shell gun elevation order dials on 1200', from both increasing and decreasing directions.

for mods 1 and 2:

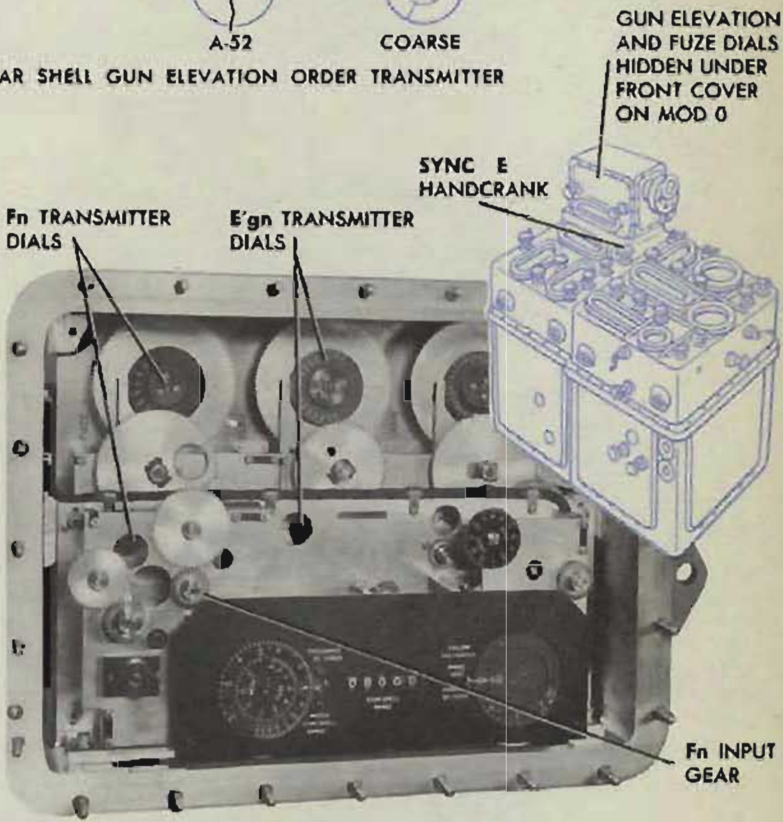
Put the star shell elevation handcrank in the SEARCH position and set the star shell gun elevation order dials on 1200', from both increasing and decreasing directions.

5 At the gun mounts, read the received value on the elevation dials for each direction of transmitter setting.

6 Continue the test in the same manner for *E'gjn* values of 2000', 2900', 4000', 4500', and 5200'.



STAR SHELL GUN ELEVATION ORDER TRANSMITTER



MOD 0

Checking Fn transmission

1 Set up the fire control switchboard to transmit star shell fuze setting order to each gun mount.

2 At the computer,

for mod 0:

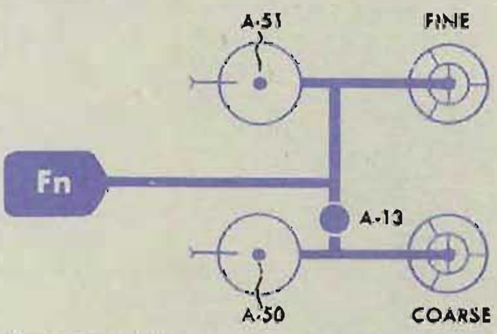
Turn the *Fn* input gear to set the *Fn* dials at 9.00 seconds, from both increasing and decreasing directions.

for mods 1 and 2:

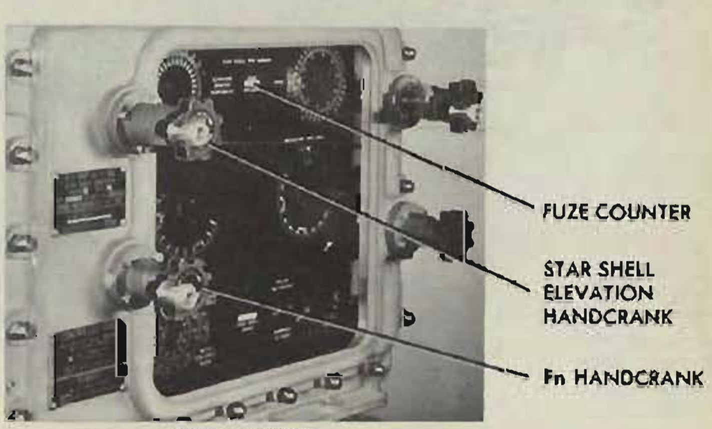
Use the *Fn* handcrank in the IN position to set the star shell fuze counter on 9.00 seconds, from both increasing and decreasing directions.

3 At the gun mounts, read the error on the fuze setting indicator regulator for each direction of transmitter setting.

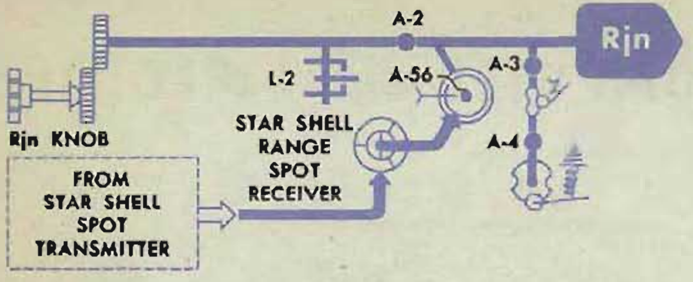
4 Continue the test in the same manner for *Fn* values of 15.30, 21.60, 27.90, 34.20, and 40.50 seconds.

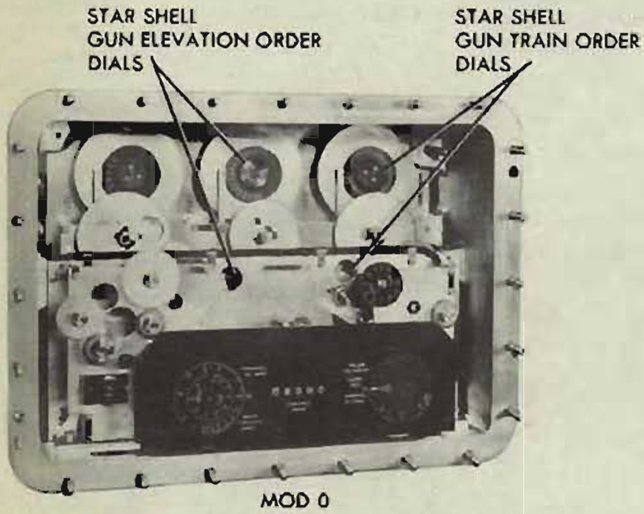


STAR SHELL FUZE ORDER TRANSMITTER

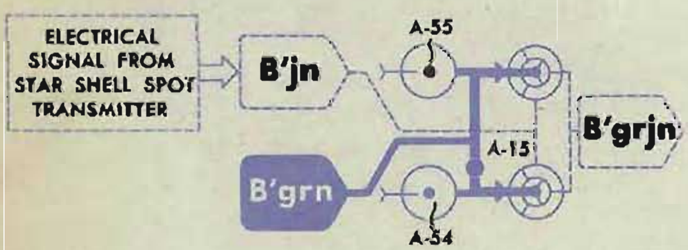


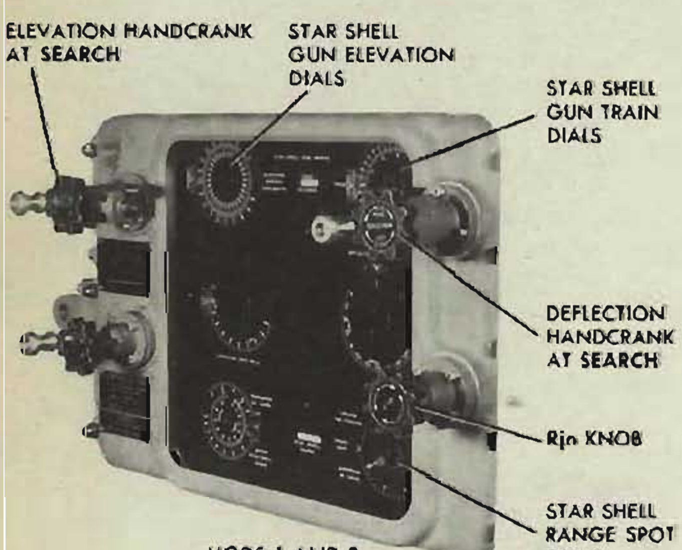
MODS 1 AND 2



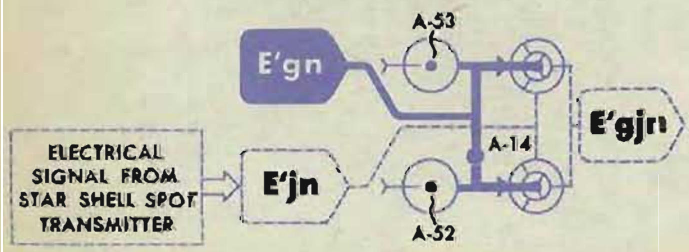


MOD 0





MODS 1 AND 2



Checking Rjn transmission

1. Set up the fire control switchboard to transmit star shell range spot to the star shell computer.
2. At the director, set star shell range spot at IN 1500 yards.
3. At the computer, match the star shell range spot dials and check that they read IN 1500 yards.
4. Continue the test in the same manner with range spot values of IN 900, IN 300, 0, OUT 300, OUT 900, and OUT 1500 yards.

Checking B'jn transmission

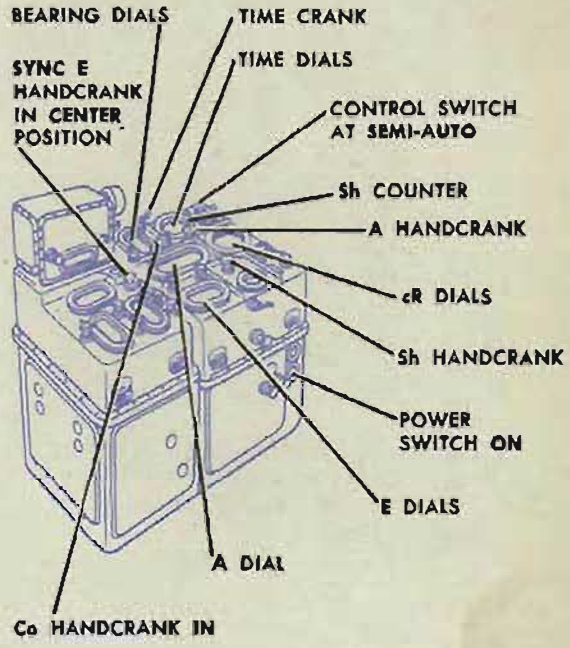
1. Set up the fire control switchboard to transmit star shell deflection spot to the star shell computer, and star shell gun train order to the guns.
2. At the gun mounts, put the guns in AUTOMATIC control.
3. At the star shell computer, set the star shell gun train order transmitter at 270°.
4. At the director, set star shell deflection spot at RIGHT 100 mils.
5. At the guns, read the gun train dials. They should now read 275°44'.
6. At the director, set star shell deflection spot at LEFT 100 mils.
7. At the guns, read the gun train dials. They should now read 264°16'.

Checking E'jn transmission

1. Set up the fire control switchboard to transmit star shell elevation spot to the star shell computer, and star shell gun elevation order to the guns.
2. At the gun mounts, put the guns in AUTOMATIC control.
3. At the star shell computer, set the star shell gun elevation order transmitter at 2000'.
4. At the director, set star shell elevation spot at UP 100 mils.
5. At the guns, read the gun elevation dials. They should now read 2344'.
6. At the director, set star shell elevation spot at DOWN 100 mils.
7. At the guns, read the gun elevation dials. They should now read 1656'.

ROUND ROBIN TEST — COMPUTER and DIRECTOR

A test of bearing, elevation, and range transmission between the computer and the director can be made instead of tests of the individual unit transmission. If excessive errors are found, the individual transmission checks should then be made to locate the errors.



Running the bearing test

At the fire control switchboard:

1 Energize director train transmission and bearing correction transmission.

At the director:

1 Energize the train motor.
2 Set the train selector lever in AUTO.
3 Set director train at 0°.
4 Stand by without moving the handwheels.

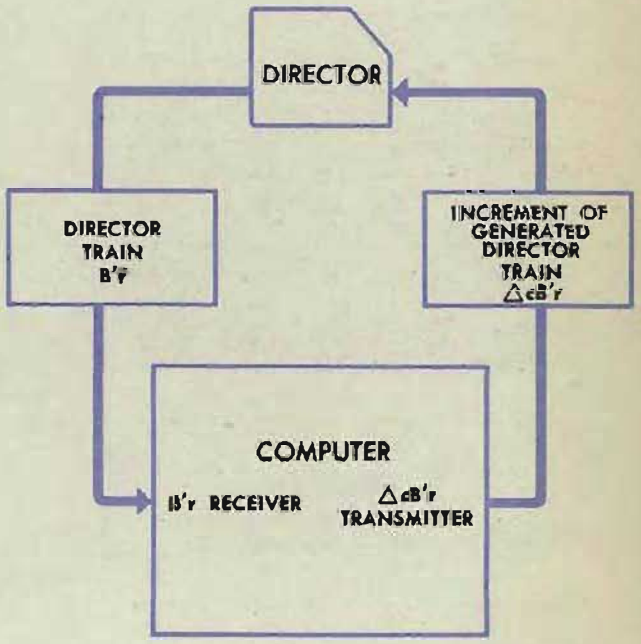
At the computer:

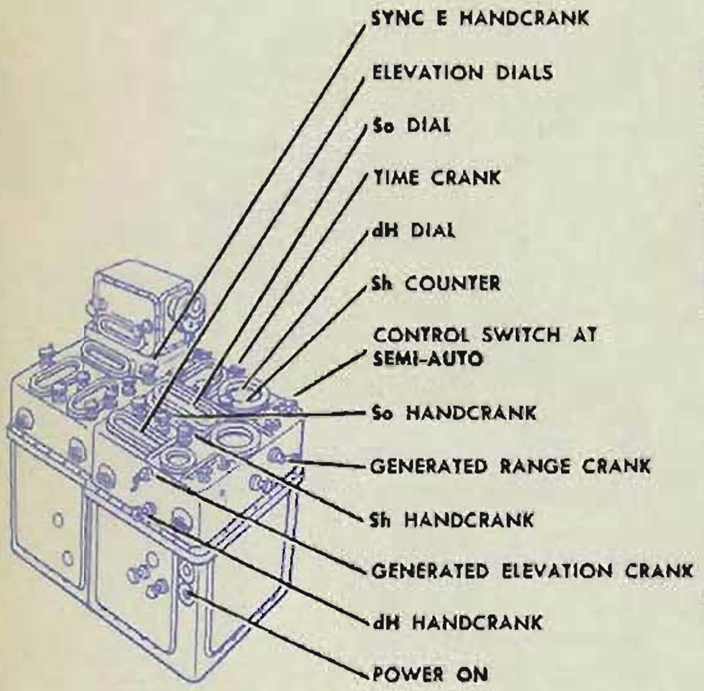
1 Turn the power ON.
Turn the control switch to SEMI-AUTO.
Set *L* and *Zd* at 2000′.
Set *A* at 90°.
Set *E* at 0°.
Set *Sh* at 300 knots.
Set *cR* at 3000 yards.
Put the *Co* handcrank IN.
2 Turn the time crank in the OUT position slowly and smoothly until at least 10° of bearing have been generated. Check that observed bearing turns smoothly and remains matched with generated bearing.
3 Repeat this procedure, starting with *A* at 270°.

Checking the overall transmission error

At the computer:

1 Set *A* at 90°.
2 Turn the time crank in the OUT position until observed bearing is on a definite value.
3 Turn the generated bearing crank in the OUT position and match one index of the fine inner dial to the 0 index of the fine ring dial.
4 Turn the time crank again until observed bearing increases about 1°.
5 Set *A* at 270°.
6 Turn the time crank until observed bearing is set at the value chosen in step 2.
7 Read the fine bearing dials. The difference between the previously chosen index of the inner dial and the 0 index of the ring dial represents the system error.





Running the elevation test

At the fire control switchboard:

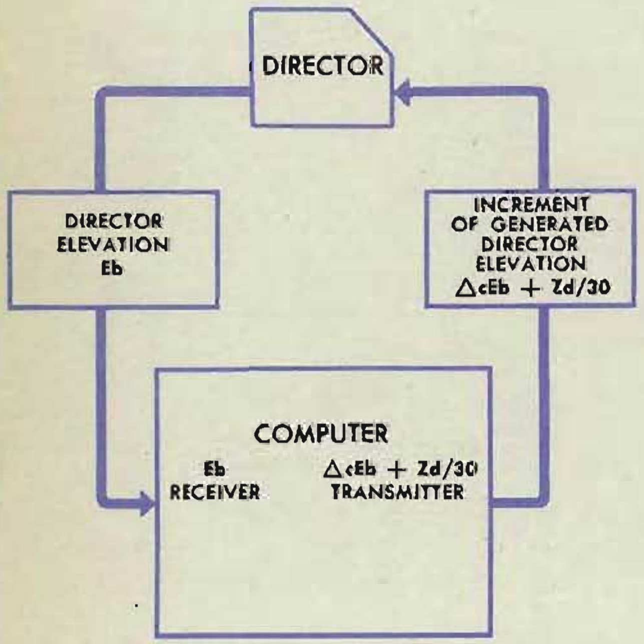
1 Energize director elevation transmission and elevation correction transmission.

At the director:

1 Energize the elevation motor.
2 Set the elevation selector lever in AUTO.
3 Set director elevation at 0.
4 Stand by without moving the handwheels.

At the computer:

1 Turn the power ON.
Turn the control switch to SEMI-AUTO.
Set *L* and *Zd* at 2000′.
Set *So* and *Sh* at 0 knots.
Set *dH* on CLIMB 150 knots.
Set *cR* on 2000 yards. Match the sync *E* dials at the index with the sync *E* hand-crank in the IN position.
2 Turn the time crank in the OUT position slowly and smoothly until at least 10° of elevation have been generated.
3 Check that observed elevation turns smoothly and stays matched with generated elevation.
4 Repeat this procedure with *dH* at DIVE 150 knots.



Checking the overall transmission error

1 Reset *dH* at CLIMB 150 knots.
2 Turn the time crank in the OUT position until observed elevation is set on a definite value.
3 Match one index of the fine inner dial to the 0 index of the fine ring dial with the generated elevation crank in the OUT position.
4 Turn the time crank again until observed elevation increases about 1°.
5 Set *dH* at DIVE 150 knots.
6 Turn the time crank again until observed elevation is on the same definite value chosen in step 2.
7 Read the fine elevation dials. The difference between the previously chosen index of the inner dial and the 0 index of the ring dial represents the system error.

Running the range test

At the fire control switchboard:

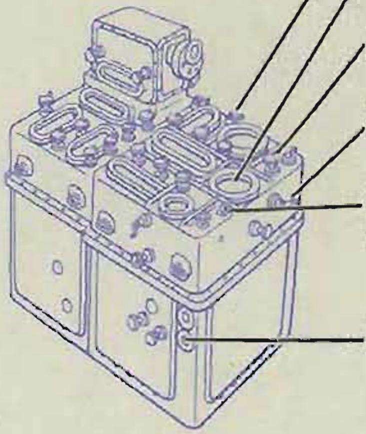
1 Energize range transmission and range correction transmission.

At the director:

1 Turn the change of range receiver ON.
2 Turn the range selector switch to RANGE FINDER.
3 Set optical range at 10,000 yards.
4 Stand by without changing range.

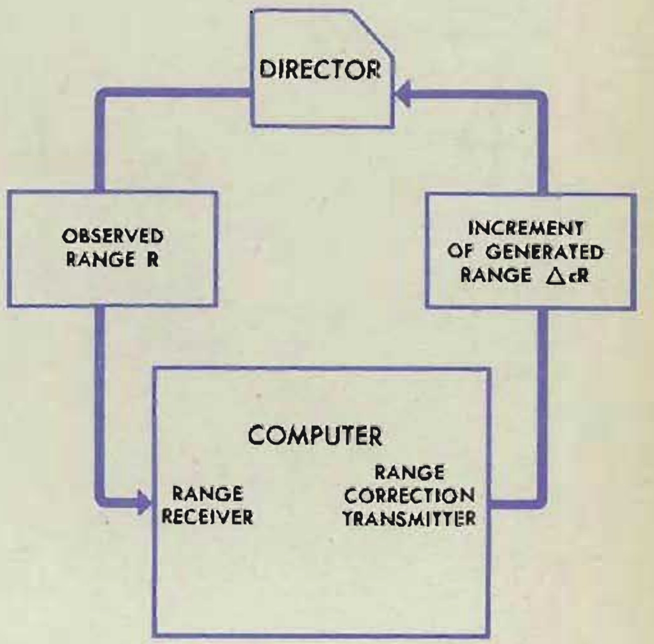
At the computer:

1 Turn the power ON.
Turn the range rate control switch to MANUAL.
Set *cR* at 10,000 yards.
Put the *dR* handcrank in HAND and set in a large positive rate.
2 Turn the time crank in the OUT position slowly and smoothly until at least 1000 yards range have been generated.
3 Check that observed range turns smoothly and stays matched with generated range.
4 Repeat this procedure with *dR* set at a large negative value.

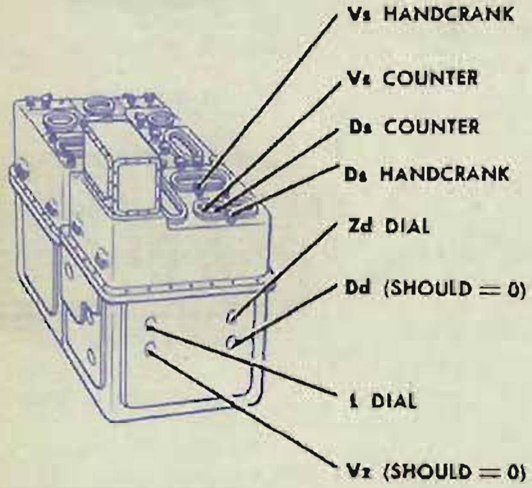


Checking the overall transmission error

1 Set *dR* at a large positive value.
2 Turn the time crank slowly until the index of the fine observed range dial is at the fixed index.
3 Match the generated range dial index exactly at the fixed index with the generated range crank in the OUT position.
4 Turn the time crank slowly until *cR* has increased about 500 yards.
5 Set *dR* at a large negative rate.
6 Turn the time crank slowly until *cR* is again at the value set in step 3.
7 The difference between the observed and generated dials represents the system error.



OVERALL TRANSMISSION SYSTEM CHECK



An overall check of train and elevation transmission can be made instead of the individual unit check tests. If excessive errors are found, the individual transmission checks should be made to determine the source of error. The overall check is made by transmitting values from the director through the computer to the gun mounts.

Making the overall check

At the fire control switchboard:

1 Energize train and elevation transmission from the director to the computer, and from the computer to each gun mount.

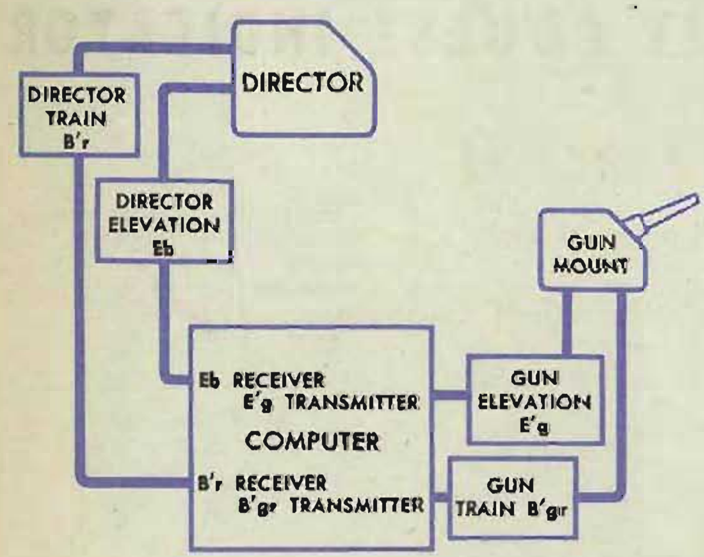
At the computer:

1 Energize and set up the computer to receive *B'r* and *Eb*.

2 Set *L*, *Zd*, and *Vs* at 2000'.
Set *Ds* at 500 mils.
Dd and *Vz* should now be at 0, with *B'gr* equal to *B'r*, and *E'g* equal to *Eb*.

At the director:

1 Set *B'r* and *Eb* at suitable values.
The director train indicator and the director elevation indicator dials should be brought on to these values slowly and carefully. The director may be operated in LOCAL control to approach the value, but to obtain an accurate setting, MANUAL control should be used. Set the director dials first in the increasing direction and then in the decreasing direction from an offset of approximately 2°.



At the gun mounts:

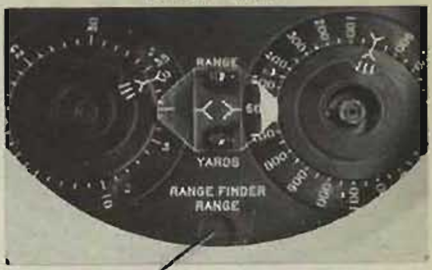
1 Energize the mounts and put them in AUTO.

2 Read the transmitted values on the train indicator regulator and the elevation indicator regulator dials.
The difference between the reading at the gun mount and the value set at the director is the total system error.

NOTE:
When the fire control switchboard is set up for indicating transmission only, the mount should be shifted to LOCAL and the reading taken after pointers are matched.

CHECKING THE SIGNAL FLAGS

RANGE DIALS

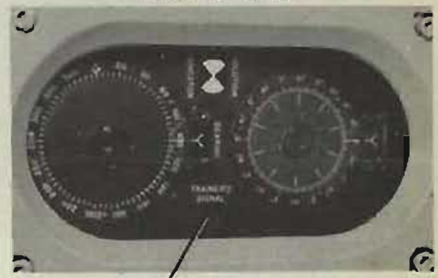


RANGE FINDER'S SIGNAL FLAG

Range finder's signal flag

1 Energize the range transmission circuit and turn the power switch ON.
2 Check that the range finder's signal flag shows white when the range finder's signal key is closed.
3 Check that it releases and shows black when the signal key is open.

BEARING DIALS



TRAINER'S SIGNAL FLAG

Trainer's signal flag

1 Energize the bearing transmission circuit and turn the power switch ON.
2 Check that the trainer's signal flag shows red when the trainer's signal key is closed.
3 Check that it releases and shows black when the signal key is open.

ELEVATION DIALS

POINTER'S SIGNAL FLAG

Pointer's signal flag

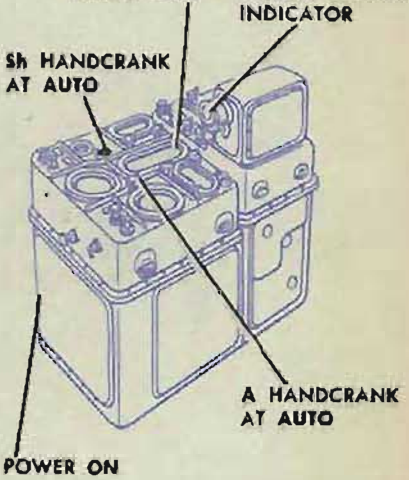
1 Energize the elevation transmission circuit and turn the power ON.
2 Check that the pointer's signal flag shows red when the pointer's signal key is closed.
3 Check that it releases and shows black when the signal key is open.

If a signal flag fails to operate, makes excessive noise, or sticks, see OP 1140A, Solenoid Signal Mechanism.

CHECKING THE TARGET COURSE INDICATOR

Operation

1 Turn the power switch ON.
2 Put the *Sh* and *A* handcranks in AUTO.
3 Depress the INCREASE button on the target course indicator.
Ct on the indicator should increase, and *A* on the computer target dial should decrease.
4 Depress the DECREASE button and check the operation in the opposite direction.



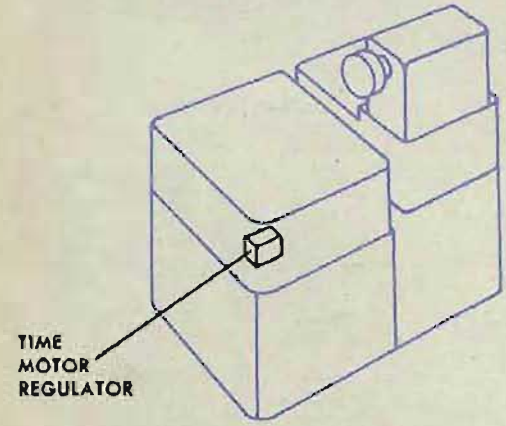
Transmission

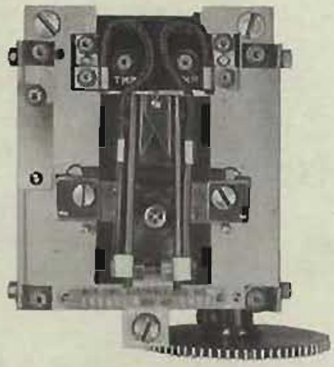
1 Set *B* at 0°.
2 Set *A* at each value listed below, and check that the target course indicator reads the corresponding value of *Ct*.

A–	120°	60°	0°	300°	240°	180°
Ct–	60°	120°	180°	240°	300°	360°

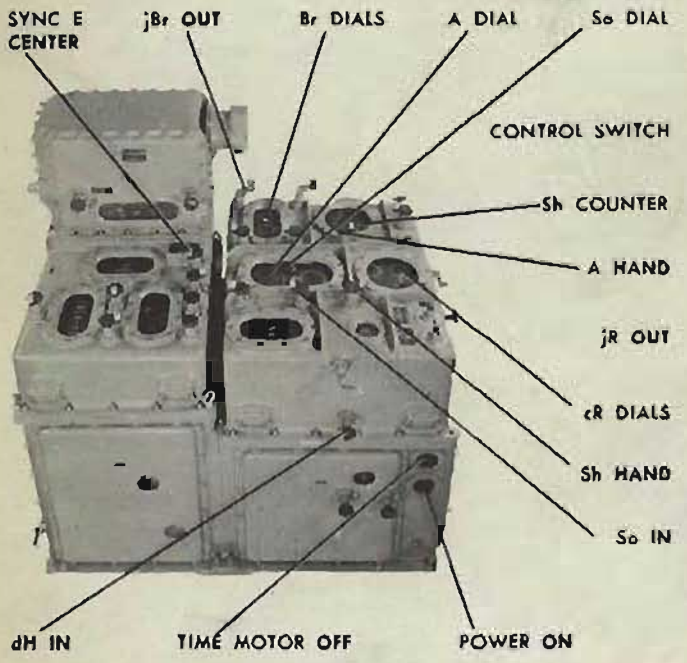
If the target course indicator does not operate correctly, see Locating Casualties, Target Course Indicator, page 566.

THE TIME MOTOR REGULATOR TEST





TIME MOTOR REGULATOR



The time motor regulator is tested by checking the speed of the time motor output with a stop watch. This test should be run as prescribed in the Log Book NAVORD FORM 1229, and should always be run when excessive errors occur in the B tests.

Before running the test

First, check that the power supply voltage to the computer is 115 ± 10 volts and that the frequency is 60 cycles ± 10%. Then:

1 Energize the computer power circuit at the fire control switchboard.

2 Turn the computer power switch ON.

3 Turn the time motor switch OFF.

4 Turn the control switch to SEMI-AUTO.

Set the following values into the computer to obtain an average load on the time motor shaft line:

Set *So* at 50 knots with the ship speed handcrank IN.

Set *Sh* at 600 knots with the target speed handcrank at HAND.

Set *dH* at −400 knots with the rate of climb handcrank IN.

Set *Br* at 135° with the generated bearing crank OUT, and the control switch at LOCAL.

Set *A* at 135° with the target angle handcrank at HAND.

Set *E* at 45° with the synchronize elevation handcrank at CENTER.

Set *cR* at 5000 yards with the generated range crank OUT.

Return the control switch to SEMI-AUTO.

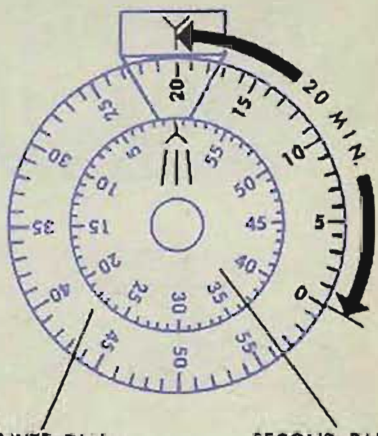
dR KNOB IN HAND + dR ON ZERO

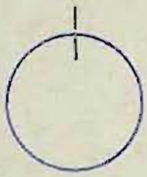
Running the test

Turn the time motor switch ON.

Let the time motor run for at least one minute so that the regulator can take control.

Then, using a stop watch, measure the number of seconds that elapse during any twenty-minute period on the time dial.





HALF-SECOND DIAL

Recording test results

Record the results of the time motor regulator test on a time motor regulator test record form, in the log book.

Under *Time, Stop Watch*, enter the total number of seconds indicated on the stop watch for the twenty-minute dial movement.

Under *Error, Seconds*, enter the number of seconds over or under 20 minutes 0 seconds recorded on the stop watch. If the stop watch reading is over 20 minutes 0 seconds, the error is minus, and the time shaft line is turning too slow. If the reading is under 20 minutes 0 seconds, the error is plus, and the time shaft is turning too fast.

Under *Error, Seconds per Minute*, enter the error divided by twenty.

Adjusting the time motor regulator

If the error is greater than ±0.05 second per minute, the regulator may require adjustment. See *Locating Casualties, Time Motor Regulator*, page 562.

TIME MOTOR REGULATOR TESTS
RECORD OF TESTS

DATE	VOLTS AC SUPPLY	TIME STOP WATCH	ERR. SEC.	ERR. SEC./MIN.	DATE	VOLTS AC SUPPLY	TIME STOP WATCH	ERR. SEC.	ERR. SEC./MIN.
3 May 46	118	20 min. 0.8 sec.	-0.8	0.04					

TABLES OF OPERATING LIMITS

These tables list all limit stops and intermittent drives and the limits of operation of each. Limits of operation for the computer generally apply to Mod 7. Limits for the star shell computer apply to Mods 0, 1, and 2 as indicated.

These tables of operating limits are used when A or B test results indicate faulty operation. Then the limit stops and intermittent drives in the networks in error should be checked. The adjustment clamp associated with each limit stop is listed in the tables. For clamp locations, modification differences, and readjustments, refer to the *Readjustment Procedure*.

If any limit stop or intermittent drive requires readjustment, all adjustments on the line should be checked. To locate adjustment points on the line, consult a schematic diagram. To check these adjustments, refer to the *Readjustment Procedure*.

OPERATING LIMITS – INTERMITTENT DRIVES

INTERMITTENT DRIVE	LIMITS		ADJUSTMENT CLAMP
	LOWER	UPPER	
cR	750 Yds.	22,500 Yds.	A-233
E	-2°	+85°	A-250
E_2	0°	90°	A-72
dRs	-450 Kn.	+450 Kn.	A-181
Ds	320'	680'	A-96
Eb+Vs	1640'	7160'	A-60
Vs	2000'	3800'	A-97
R_2	1500 Yds.	18,900 Yds.	A-156

OPERATING LIMITS – STAR SHELL COMPUTER MK. 1

LIMIT STOP NUMBER	QUANTITY	LIMITS		ADJUSTMENT CLAMP
		LOWER	UPPER	
L-1	WrD + KRdBs	-60 Kn.	+60 Kn.	A-6, Mods 0,1,2
L-2	Rjn	IN 1500	OUT 1500	A-2, Mod 0
L-2	Rjn	IN 2857	OUT 1500	A-2, Mod 1
L-2	Rjn	IN 2700	OUT 1500	A-2, Mod 2
L-3	Fn	8.20 secs.	41.55 secs.	A-16, Mod 0
L-3	Fn	8.20 secs.	41.55 secs.	A-19, Mod 1
L-3	Fn	9.70 secs.	46.70 secs.	A-19, Mod 2
L-4	jDwn	4000 Yds.	15,000 Yds.	A-5, Mods 0 and 1
L-4	jDwn	8000 Yds.	19,500 Yds.	A-5, Mod 2

OPERATING LIMITS – LIMIT STOPS, COMPUTER MK. I

LIMIT STOP NUMBER	QUANTITY	LIMITS		ADJUSTMENT CLAMP
		LOWER	UPPER	
L-1	So	0	45 Kn.	A-527
L-2	Sh	0	400 Kn.	A-193
L-3	Sw	0	60 Kn.	A-528
L-4	dH	-250 Kn.	+150 Kn.	A-525
L-5	dRh	-440 Kn.	+440 Kn.	A-119
L-6	RdBs	-400 Kn.	+400 Kn.	A-121
L-7	RdE	-400 Kn.	+400 Kn.	A-118
L-8	dR	-450 Kn.	+450 Kn.	A-524
L-9	Ywgr	-100 Kn.	+100 Kn.	A-101
L-10	cR	0	35,000 Yds.	A-196
L-11	Eb	500'	8600'	A-90
L-12	E	-25° 00'	+85° 00'	A-116
L-13	Rrr	1	5	A-172
L-14	Tg	0	6 secs.	A-535
L-14	Tg + F - Tf	0	50 secs.	A-262
L-15	I.V.	2350 f.s.	2600 f.s.	A-536
L-16	L	480'	3520'	A-58
L-17	Zd	480'	3520'	A-30
L-18	jB'r	-11° 40'	+11° 40'	A-199
L-19	R_2	500 Yds.	18000 Yds.	A-74
L-20	Tf / R_2	.00122	.00336	A-38
L-21	R_2	300 Yds.	18,200 Yds.	A-41
L-22	Vf + Pe	0	2500'	A-14
L-23	R_2	300 Yds.	18,200 Yds.	A-16
L-24	Tf	0.6 sec.	60.6 secs.	A-19
L-25	R_2	300 Yds.	18,200 Yds.	A-21
L-26	DISCONTINUED			
L-27	DISCONTINUED			
L-28	Dfwj	-518 mils	+518 mils	A-198
L-29	Rj	IN 12,000	OUT 1800	A-234 A-235
L-30	Dj	LEFT 180	RIGHT 180	A-500
L-31	Vj	DOWN 180	UP 180	A-501
L-32	Dd	-120°	+120°	A-31
L-33	UNASSIGNED			
L-34	Vz	-2940'	+1860'	A-29
L-35	F	0.6 sec.	55.0 secs.	A-45
L-36	R_3	-1250 Yds.	+19,750 Yds.	A-47
L-36	R_3	-13,150 Yds.	+31,650 Yds.	A-48
L-37	V	200'	3800'	A-184
L-38	Tg	0	6 secs.	A-535
L-39	I.V.	2350 f.s.	2600 f.s.	A-607

Part two

ANALYSIS OF TEST ERRORS

Introduction

The following chapters on the *Analysis of Test Errors* provide a means for locating the causes of the errors, as well as methods for correcting them. The procedure described in each chapter consists of classifying the types of errors, determining the conditions under which the errors exist, and, finally, locating the unit or mechanism actually causing the errors. The method of correcting the errors will depend upon the nature of the trouble. It is essential for the test operator to be familiar with OP 1140, which describes the function and operation, and OP 1140A, which describes the maintenance, of the various standard units. Also, in this OP, the section on *Locating Casualties* should be studied frequently so that the operator will be able to recognize typical troubles.

Whenever the results of a test problem show excessive errors, the problem should be completely rechecked. After checking the error calculations, reread all of the problem setup values. Then move all of the input quantities off their settings. Repeat the setup and rerun the test problem. If the excessive errors no longer exist, although no mistake was made originally in the setup or error calculation, the trouble was probably due to sticking in a unit or shaft line, and moving an input quantity released it. The exact cause of the trouble should be located and corrected. If the large errors persist, the next step is to run several other test problems, preferably the complete set, to gain information for analysis of the errors. However, if any apparent symptoms of trouble such as binding of lines, erratic operation, or unusual noises, appear in the course of running a test, the instrument should be secured and the trouble located before proceeding further with the test.

In correcting an excessive error, the loosening and readjustment of a clamp should not be attempted until all other possible causes of the error have been eliminated. Adjustment clamps do not slip without reason. If it is decided that a clamp has slipped, try to tighten it before starting to loosen it for readjustment. If the clamp can be tightened further, it may reasonably be assumed that the clamp slipped during normal operation. If the clamp is already tight, and seems to hold the adjustment properly, keep checking until the cause of the adjustment error is located.

A TEST ANALYSIS

This test analysis provides a method of finding and correcting A test errors. To find the cause of these errors, the type of errors should be determined first. Then all the networks in error can be found, and the network causing the errors and the exact cause of the error in that network can be located and corrected. Several additional A test problems should be run before any attempt is made to locate and correct the errors. This eliminates the possibility that the errors were introduced by faulty setup of the problem or by mistakes in computation.

TYPES OF ERRORS

A test errors can be divided into two types: small errors and large errors.

Small errors in a transmitted quantity are errors that are greater than the allowable average, but are within the allowable maximum.

Large errors in a transmitted quantity are errors which exceed the allowable maximum. *Large errors should be located and corrected.*

CAUSES OF ERRORS

Small errors, or errors that have gradually increased over a period of time, are usually due to wear in the computer. Errors due to wear generally require repair to reduce lost motion in the units and shaft lines.

Large errors in the transmitted quantities are usually caused by a dead or faulty follow-up, a mechanical defect in a shaft line or mechanism, a disengaged coupling, or an adjustment error. By comparing the instrument readings with the A test computed intermediate quantities, all the networks in error can be determined. When all the networks in error are known, the network causing the error can be found and the source of the error located.

Determining the networks in error

Each transmitted quantity is computed in several networks. The independent variables are the inputs to the first group of networks. The outputs of these networks are the intermediate quantities which are, in turn, inputs to several other networks. The transmitted quantities are the outputs from the final group of networks. Therefore, the cause of error in a transmitted quantity may be in any one of several networks. Errors in more than one of the transmitted quantities are usually caused by an error in an intermediate network.

To find the intermediate networks in error, the dial or counter reading of each intermediate quantity should be checked against its value on the A test record form for the problem setup in the instrument. When an intermediate quantity is correct, all the quantities used in computing it are correct. When an intermediate quantity is in error, its network or one or more of its network inputs are also in error.

Locating the cause of error in a network

When the network causing the errors is determined, any follow-ups in the network should be checked. Then all shaft lines and computing mechanisms should be carefully inspected for mechanical defects. If no mechanical defects are found, all dials and counters in the network should be checked against their limit stops. After all these checks have been made, the adjustments in the network should be checked, beginning with the last adjustment known to be correct.

Checking follow-ups

The following zero test can be used to check the operation of all the follow-ups before checking the individual networks:

1 Set the computer for A tests, and set in the following independent variables: *Co*, *So*, *Sh*, *Sw*, *dH*, *Bw*, *Tg*, and *E* on 0; match the sync *E* dials.
Set *Rj*, *Vj*, and *Dj* on 0.
Set *Br* on 270° and *A* on 90°.
Set *L* and *Zd* on 2000′.
Set *I.V.* on 2550 f.s.
Set *cR* to make *Vs* equal 2100′.

2 Read the following transmitted and intermediate quantities, and compare the reading with the value given:
B′gr should read 270°00′ ± 5′.
E′g should read 2100′ ± 5′.
Ds should read 500 mils ± 1.5 mils.
R2 should equal *cR* ± 10 yards.
cR should read 2840 yards ± 20 yards.
Pv should read 0°.
Ph should read 2° LEFT.
F should read 3.88 sec. ± 0.05 sec.
Dd and *Vz* should read 0′.
Check the follow-ups used in computing any quantity in error.

A faulty follow-up may cause error in several ways. It may synchronize slowly or not at all. The output may be erratic or oscillating. Check the synchronization. If the follow-up is dead or faulty, refer to the chapter on follow-ups in this OP and in OP 1140A.

Checking for mechanical troubles

An error may be caused by mechanical troubles such as faulty gear meshes, jammed or broken mechanisms, foreign material in the instrument, or an adjustment which has slipped.

Turn each shaft line in the network in error to check that there is no jamming, sticking, slipping, or excessive lost motion in the lines.

If all shaft lines are in proper working condition, check the computing units in the network. A series of unit check tests are provided for this purpose on pages 190 to 227. If there are mechanical defects in any unit, refer to OP 1140A.

Checking for disengaged couplings

An Oldham coupling between two shafts may disengage and then engage again after one shaft has made one or more revolutions. This will throw the shaft line out of adjustment. A disengaged coupling may also cause a removable shaft to fall out or may cause jamming and sticking of a shaft line. Look for any shaft that may have fallen out and check that all the couplings in the network are engaged. Refer to *Shaft Line Devices*, OP 1140A.

Checking for adjustment errors

A clamp may have slipped and altered the adjustment between mechanisms, or it may have caused an error in a counter or dial reading. No readjustment should be made before the cause of a faulty adjustment is found. If mechanical trouble in a unit has caused a clamp to slip and the clamp is readjusted before the mechanical defect has been corrected, the clamp will slip again and upset the adjustment.

No readjustment should be made until the preceding adjustments on the line have been checked and the value on the line is known to be correct.

The instructions given for making readjustments should be followed *carefully*. After readjusting any clamp, all other adjustments in the network in error should be checked.

A complete set of A tests should be run after any readjustment.

Warning

Altering an adjustment to compensate for an error in one A test usually will not correct the cause of the error. Altering one quantity without removing the cause of the error merely alters the output quantity for that particular A test. In most cases, the overall results will be made worse.

THE INTERMEDIATE QUANTITIES

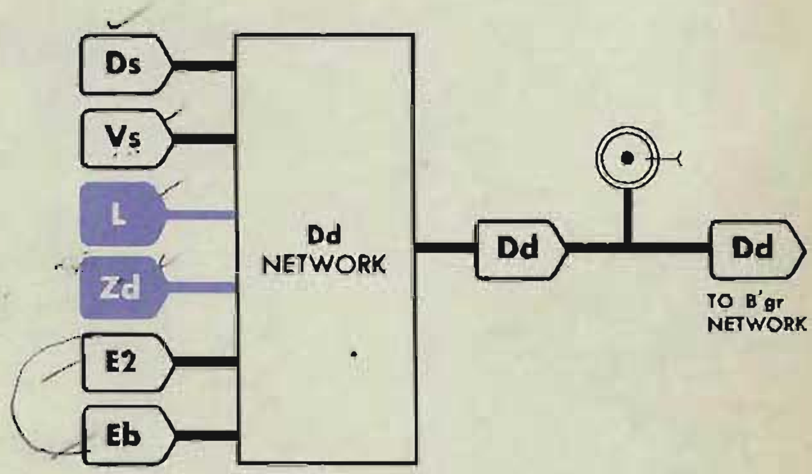
During the analysis of test errors, the intermediate quantities are set at definite values for check tests of individual units. The following section deals with the reading and the setting up of the various intermediate quantities.

The intermediate quantities given on the A test record form may be divided into three groups:

- Quantities that can be read without removing the covers.
- Quantities that can be read only after the covers are removed.
- Quantities that cannot be read.

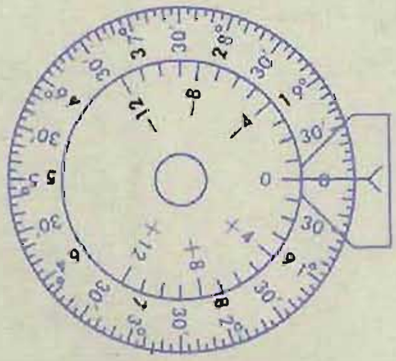
The following intermediate quantities can be read without removing any covers.

Dd Total deflection in deck plane



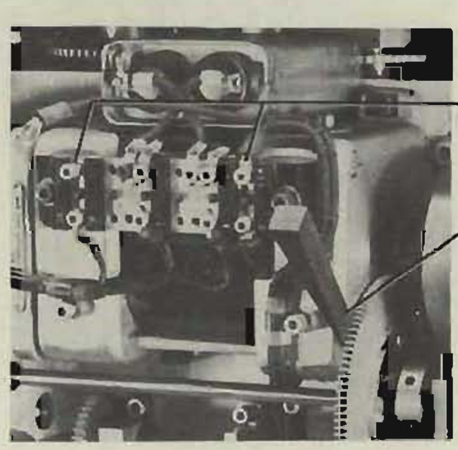
Dd will be in error if there is an error in *Ds*, *Eb*, *E2*, *Vs*, *L*, or *Zd*. *Dd* is an input to the *B'gr* network. Therefore an error in *Dd* will cause an error in *B'gr*.

Reading Dd



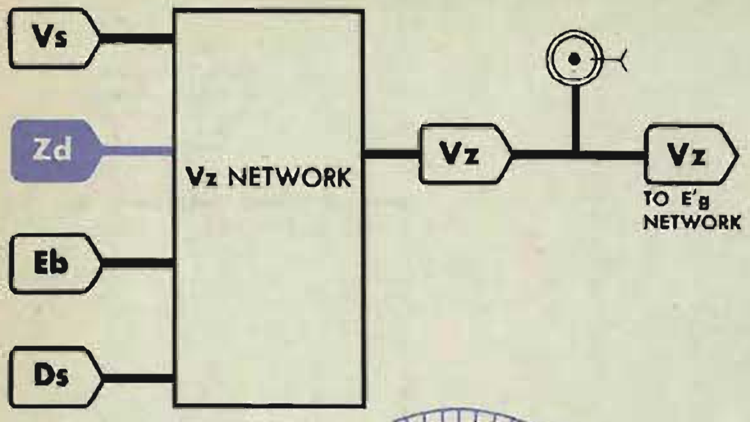
Dd can be estimated to within 1′ on the *Dd* dials at the rear of the computer. The plus values are shown in white, the minus in red.

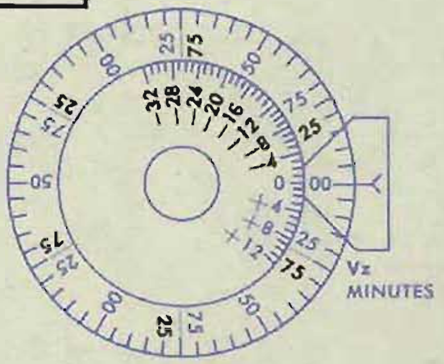
Setting Dd

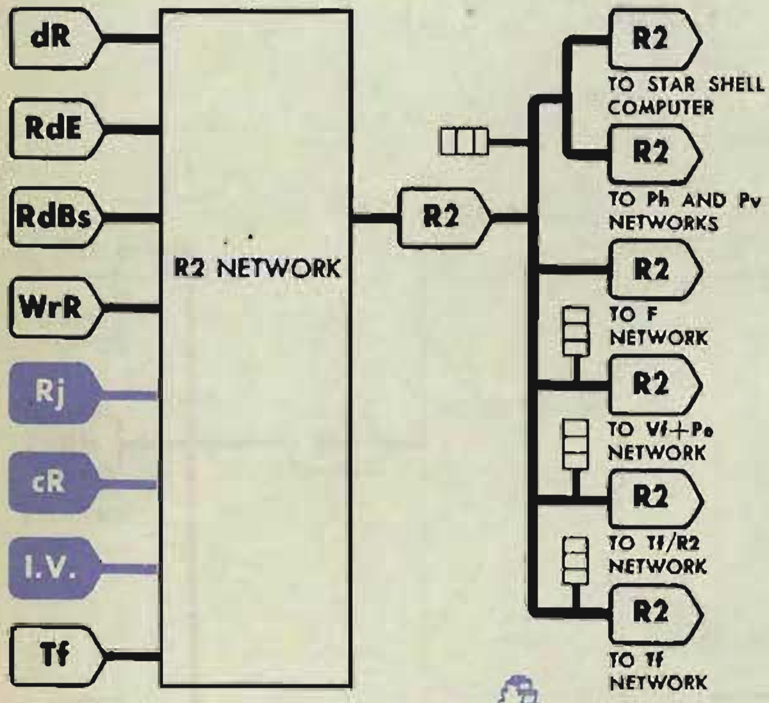


To set *Dd* at a desired value, push the *Ds* handcrank IN and turn it until that value of *Dd* is read on the *Dd* dials. As an alternative, disconnect power leads 1B and 1BB of the *Dd* follow-up and turn the output gearing by hand. When the *Dd* dials read the desired value, wedge the *Dd* follow-up output gearing.

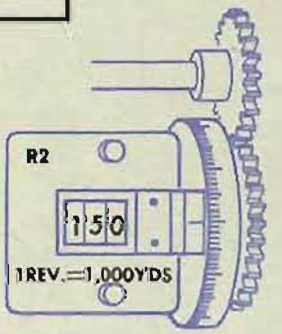
To set *Dd* at computed zero, set *Zd* at 2000′ and *Ds* at 500 mils.







R2 COUNTER READING 15,000 YDS.



Vz Trunnion tilt elevation correction

Vz will be in error if there is an error in *Vs*, *Ds*, *Eb*, or *Zd*. *Vz* is an input to the *E'g* network. Therefore, an error in *Vz* will cause an error in *E'g*.

Reading *Vz*

Vz can be estimated to within 1′ on the *Vz* dials, at the rear of the computer. The plus values are shown in white, the minus in red.

Setting *Vz*

To set *Vz* at a desired value, disconnect power leads 1D and 1DD of the *Vz* follow-up and turn the output gearing by hand. When the *Vz* dials read the desired value, wedge the *Vz* follow-up output gearing.

To set *Vz* at computed zero, set *Ds* at 500 mils and *Zd* at 2000′.

R2 Advance range

R2 will be in error if there is an error in *dR*, *RdE*, *RdBs*, *WrR*, *Tf*, *cR*, or *I.V.* *R2* is an input to the *Tf*, *Tf R2*, *Vf + Pe*, *F*, *Ph* and *Pv* networks and to the star shell computer. Therefore, an error in *R2* will cause errors in all these quantities.

Reading *R2*

R2 can be read to the nearest 5 yards on the *R2* indicating counter at the rear of the computer, or on one of the three other *R2* counters under cover 4.

Setting *R2*

To set *R2* at a desired value, turn the generated range crank in the OUT position until the *R2* indicating counter reads that value.

To set *R2* equal to *cR*, set *So*, *Sh*, *Sw*, *dH*, and *Rj* at zero, *Br* and *A* at 90°, and *I.V.* at 2550. *R2* should then equal *cR*.

Br Relative target bearing

Br will be in error if there is an error in *L*, *Zd*, or *B'r*.

Reading Br

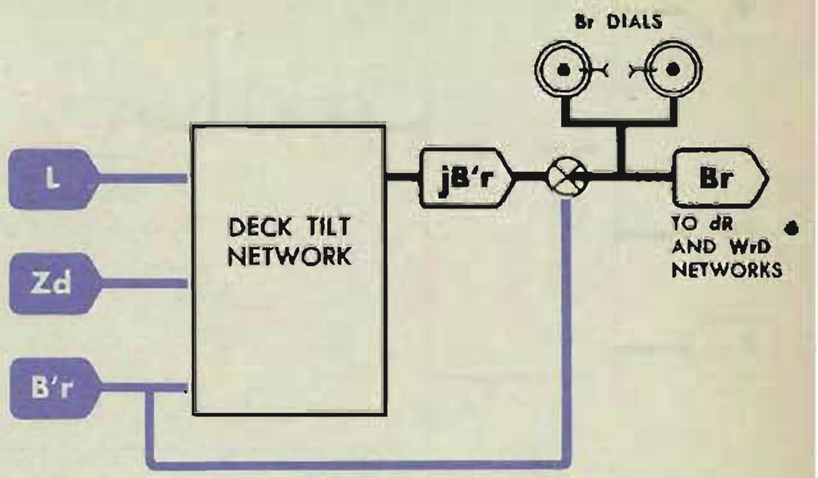
Br can be estimated to within 1′ on the bearing dial.

Setting Br

To set *Br* at a desired value, set the control switch at LOCAL and turn the generated bearing crank in the OUT position until the bearing dials read that value.

To set *Br* equal to *B'r*, set *L* and *Zd* on 2000′. *Br* should then equal the value of *B'r* being transmitted from the director.

To set *Br* equal to *B'gr*, set *L* and *Zd* on 2000′. Set *Dd* on zero. *B'r* should then equal *B'gr*.



dR Range rate-diving speed

dR will be in error if there is an error in *Br*, *E*, *So*, *Sh*, *dH* or *A*. *dR* is an input to the *R2*, *F*, and integrator networks. Therefore, an error in *dR* will cause an error in these quantities.

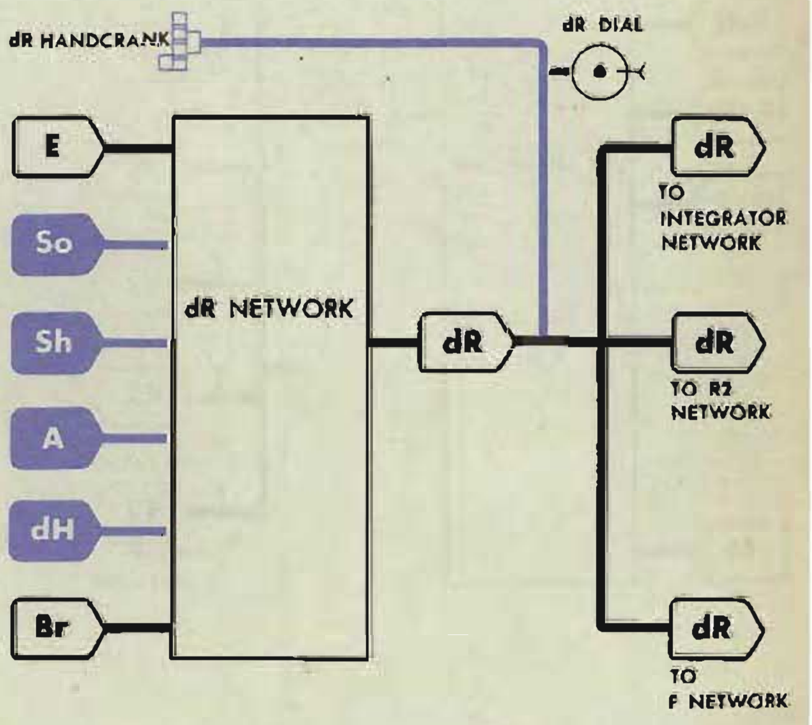
Reading dR

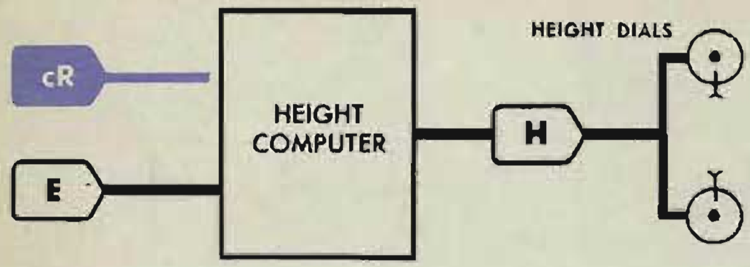
dR can be read on the *dR* dial, at the front of the computer. The *dR* dial is graduated and numbered on the negative, or diving, side only. Therefore, positive values of *dR* cannot be read. Negative values of *dR* can be estimated to within 1 knot. To check for a small error, a test should be used in which *dR* has a negative value in round numbers.

Setting dR

Set *dR* directly by turning the *dR* handcrank in the HAND position.

To set *dR* at computed zero, set *So*, *Sh*, and *dH* at zero; *dR* handcrank at AUTO.





H Height

H will be in error if *cR* or *E* is in error. *H* is an input to the height dials only.

Reading H

H can be estimated to within 5′ on the *H* dials at the front of the computer.

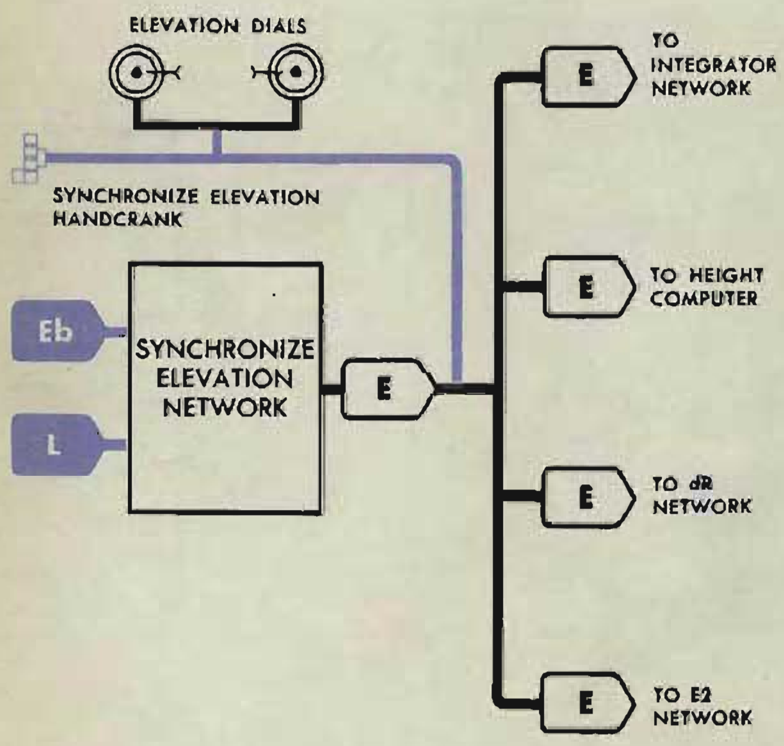
Setting H

To set *H* at a desired value, set *E* at a high value and turn the generated range crank until that value of *H* can be read on the height dials.

To set *H* at 0, set *E* or *cR*, or both, at 0.

NOTE:
Errors in *H* have no effect on any of the transmitted or intermediate quantities.

Check *H* by making the unit check test of the height computer.



E Target elevation

E is an intermediate quantity when *Eb* is received from the director.

$E = Eb - L$

E will be in error if *L* or *Eb* is in error.

E is an input to the *dR*, *E2*, *H* and integrator networks. Therefore, an error in *E* will cause an error in all these quantities.

Reading E

E can be estimated to within 1′ on the *E* dials at the front of the computer, and on either of the two *E* check counters installed in computers with Serial Nos. 435 and higher.

Setting E

To set *E*, turn the synchronize elevation handcrank in the CENTER position, until the *E* dials read the desired value.

The following intermediate quantities can be read on counters after cover is removed.

E2 Predicted angle of elevation

$E2 = E + V$

E2 will be in error if *E* or *V* is in error. *E2* is an input to the *Tf*, *Tf/R2*, *Vf + Pe*, *F*, *V*, *WrR* and *WrE*, *Dd* and *Ph* and *Pv* networks. Therefore, an error in *E2* will cause an error in all these quantities.

Reading E2

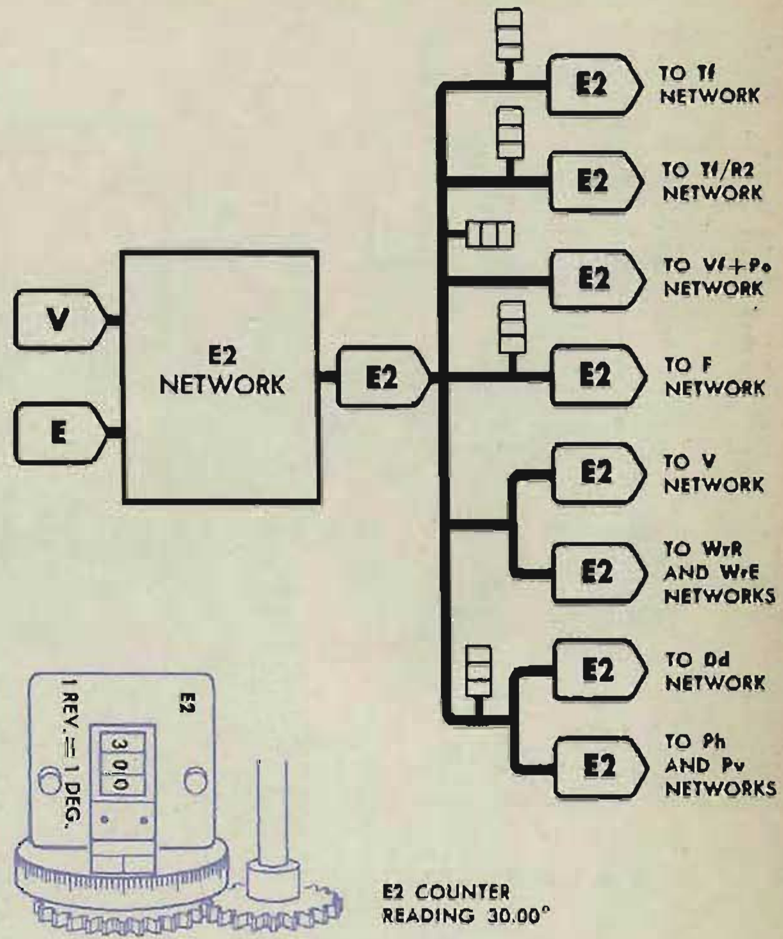
E2 can be read to within 0.01° on any of the five *E2* counters under cover 4, or on the *E2* matching counter under cover 6.

Setting E2

To set *E2*, turn the synchronize elevation handcrank in the CENTER position until the *E2* counter reads the desired value.

To set *E2* equal to *E*, set *Sw*, *So*, *Sh*, and *dH* at zero, *Br* and *A* at 90°, *Ds* at 500 mils, and *Vj* at 0 mils. Pull the sight angle handcrank OUT so that the *V* follow-up will synchronize. *E2* should now equal *E*.

ALTERNATE SETTING: Remove cover 4 and set *Vf + Pe* on zero. Set *Vs* on 2000′, and *I.V.* on 2550. *E2* should now equal *E*.



E2 COUNTER
READING 30.00°

Tf Time of flight

Tf will be in error if *E2* or *R2* is in error. *Tf* is an input to the *R2* network. Therefore, an error in *Tf* will cause an error in *R2*.

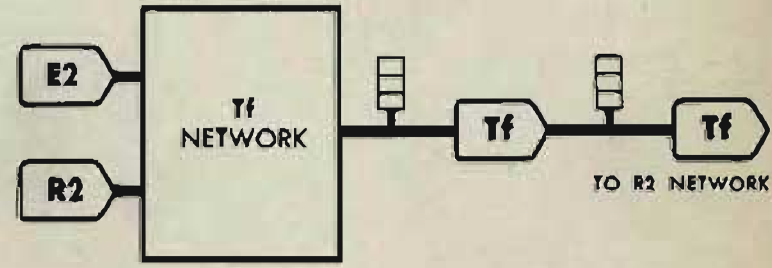
Reading Tf

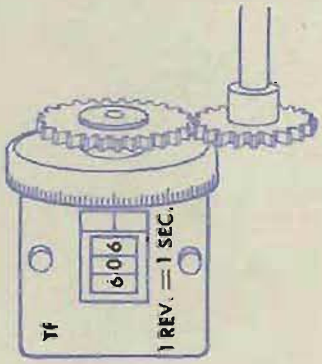
Tf can be read to within 0.01 seconds on either of the *Tf* counters under cover 4.

Setting Tf

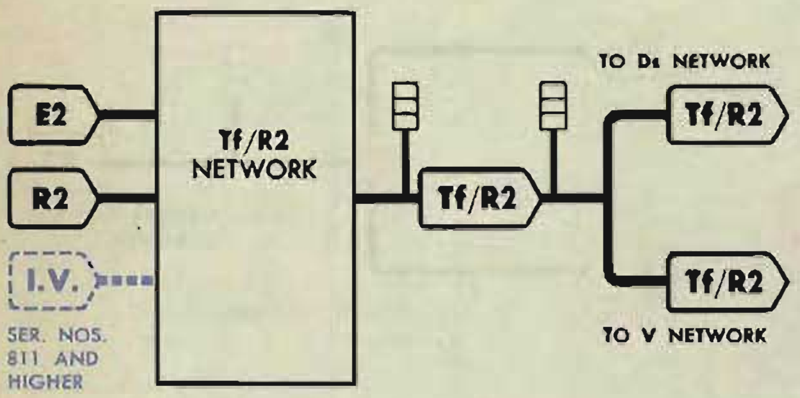
To set *Tf*, turn the power ON and turn the generated range crank in the OUT position until the *Tf* counters read the desired value.

ALTERNATE SETTING: Disconnect power leads A and AA from the *Tf* follow-up and turn the output gearing by hand. When the *Tf* counters read the desired value, wedge the *Tf* follow-up output gearing.

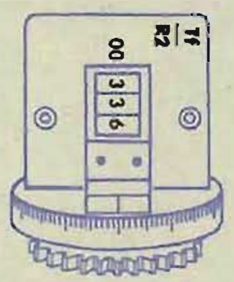


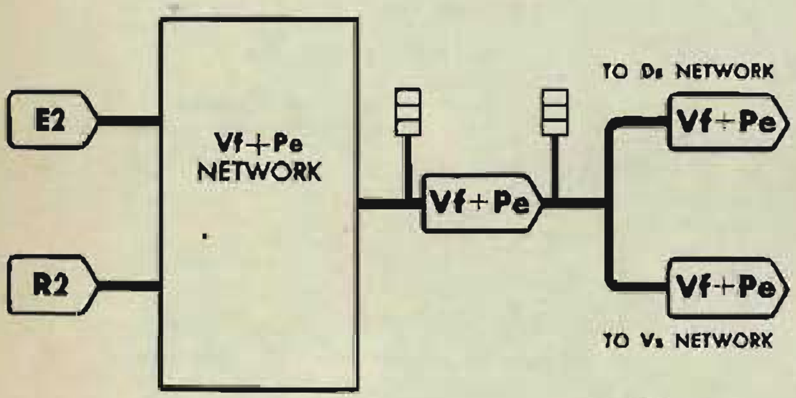


Tf COUNTER
READING 60.60 SEC.

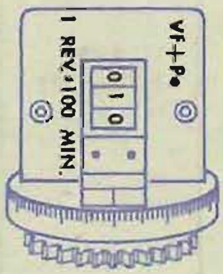


Tf/R2 COUNTER READING .003360





Vf+Pe COUNTER READING 100 MIN.



Tf/R2 Time of flight divided by advance range

Tf/R2 will be in error if *E2* or *R2* is in error. *Tf/R2* is an input to the *Ds* and *V* networks. Therefore, an error in *Tf/R2* will cause an error in *Ds* and *V*.

Reading Tf/R2

Tf/R2 can be read to within 0.000001 second per yard on either of the *Tf/R2* counters under cover 4.

Setting Tf/R2

To set *Tf/R2* at a desired value, turn the power ON, and turn the generated range crank in the OUT position until the *Tf/R2* counters read that value.

ALTERNATE SETTING: Disconnect power leads B and BB of the *Tf/R2* follow-up and turn the output gearing by hand. When the *Tf/R2* counters read the desired value, wedge the *Tf/R2* follow-up output gearing.

Vf + Pe Superelevation plus elevation parallax

Vf + Pe will be in error if *E2* or *R2* is in error. *Vf + Pe* is an input to the *Vs* and *Ds* networks. An error, therefore, in *Vf + Pe* will cause errors in *Vs* and *Ds*.

NOTE:
Vf + Pe has only a small effect on *Ds*.

Reading Vf+Pe

Vf + Pe can be read to within 1′ on either of the two *Vf + Pe* counters under cover 4.

Setting Vf+Pe

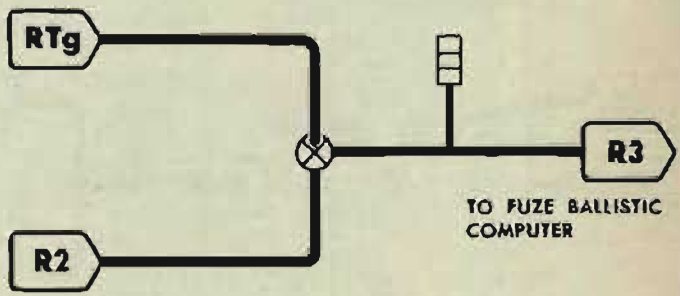
To set *Vf + Pe*, turn the power ON and turn the generated range crank in the OUT position until the *Vf + Pe* counter reads the desired value.

ALTERNATE SETTING: Disconnect power leads C and CC of the *Vf + Pe* follow-up and turn the output gearing by hand. When the *Vf + Pe* counters read the desired value, wedge the *Vf + Pe* follow-up output gearing.

R3 Fuze range

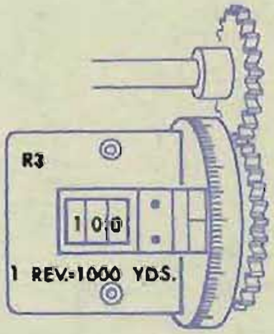
$R3 = R2 + RTg$

R3 will be in error if *R2*, *dR* or *Tg* is in error. On Serial Nos. 781 and higher, errors in *Tf*, *F*, *I.V.*, *RdBs* or *RdE* will also cause errors in *R3*. *R3* is an intermediate quantity in the *F* network, and is used in computing the transmitted quantity of fuze. Therefore, an error in *R3* will cause an error in *F*.



Reading R3

R3 can be estimated to within 1 yard on the *R3* counter under cover 4.



R3 COUNTER READING 10,000 YDS.

Setting R3

To set *R3*, turn the generated range crank in the OUT position until the *R3* counter reads the desired value.

To set *R3* equal to *R2*, set *dR* and *Tg* at 0; on Serial Nos. 781 and higher, also set *RdBs* and *RdE* at 0, set *I.V.* at 2550 f.s., and set *Tf* equal to *F*.

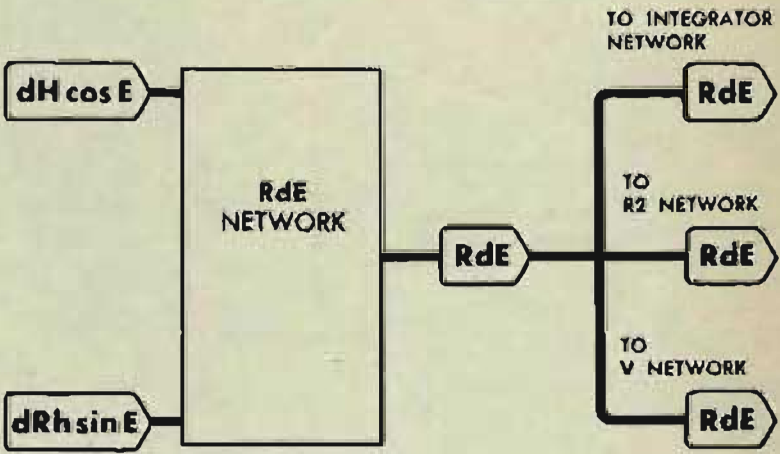
The following intermediate quantities cannot be read on any computer dial or counter. The complete network for each quantity has to be checked to determine if the quantity is in error.

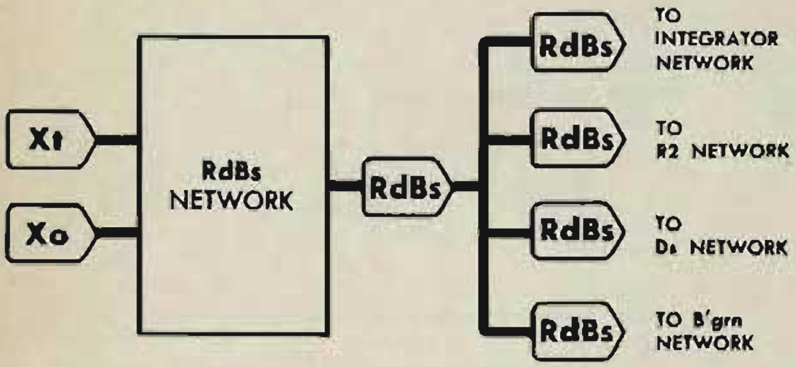
RdE Linear elevation rate

RdE will be in error if the relative motion network is in error.

RdE is an input to the *R2*, *V*, and integrator networks. Therefore an error in *RdE* will cause an error in these networks.

Values of *RdE* cannot be read because no *RdE* dial or counter is provided in the computer. See *Checking the RdE Network*, page 137.

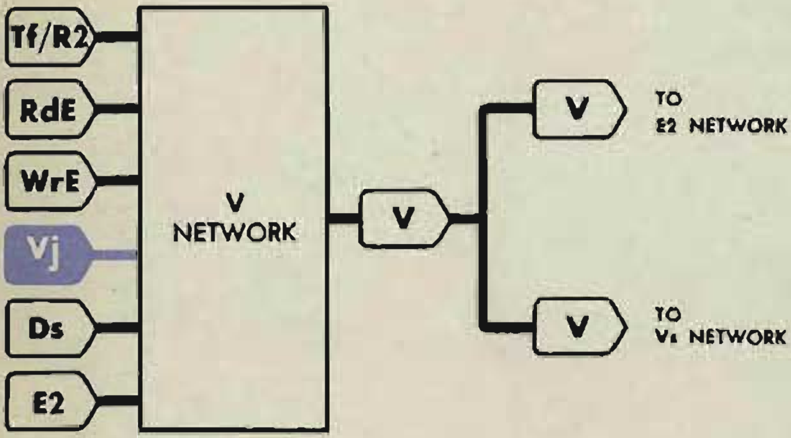




RdBs Linear deflection rate

RdBs is an input to the *R2*, *Ds*, and integrator networks and to the star shell computer. An error, therefore, in *RdBs* will cause an error in these networks.

Values of *RdBs* cannot be read because no *RdBs* dial or counter is provided in the computer. See *Checking the RdBs Network*, page 137.

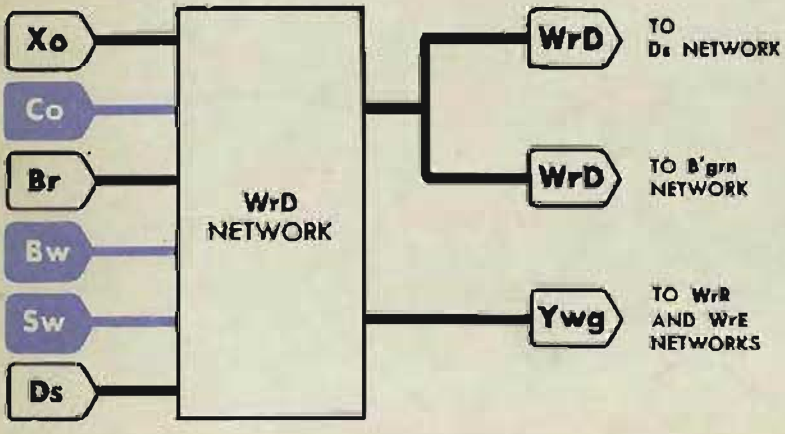


V Elevation prediction

V will be in error if there is an error in *RdE*, *WrE*, *Tf/R2*, *Ds*, *E2* or *Vj*.

V is an input to the *E2* and *Vs* networks. Therefore, an error in *V* causes an error in *E2* and *Vs*.

Values of *V* cannot be read because no *V* dial or counter is provided in the computer. See *Checking the V Network*, page 126.



WrD Apparent wind affecting deflection prediction

WrD will be in error if there is an error in *Ds*, *Sw*, *Br*, *Co*, *Xo*, or *Bw*.

WrD is an input to the *Ds* network. Therefore, an error in *WrD* will cause error in *Ds*.

Values of *WrD* cannot be read because no *WrD* dial or counter is provided in the instrument. See *Checking the WrD Network*, page 138.

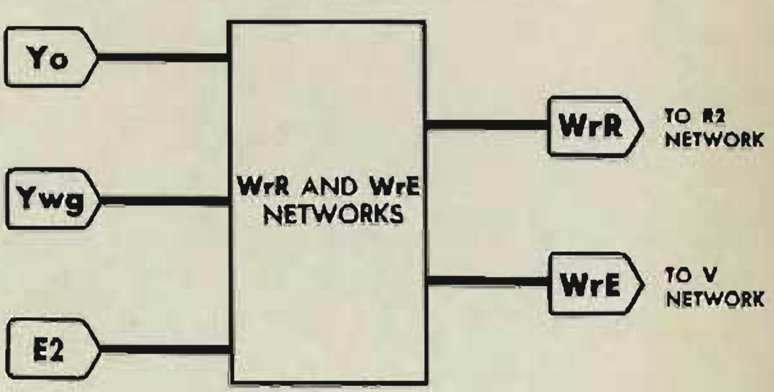
WrE Apparent wind affecting elevation prediction, and WrR Apparent wind affecting range prediction

WrE and *WrR* will be in error if *WrD* (and, therefore, *Ywg* and *Yo*) or *E2* is in error.

WrE is an input to the *V* network. Therefore an error in *WrE* will cause an error in *V* and *Vs*.

WrR is an input to the *R2* network. Therefore an error in *WrR* will cause an error in *R2*.

To check *WrE* and *WrR*, see *Checking the WrE and WrR Network*, page 128.



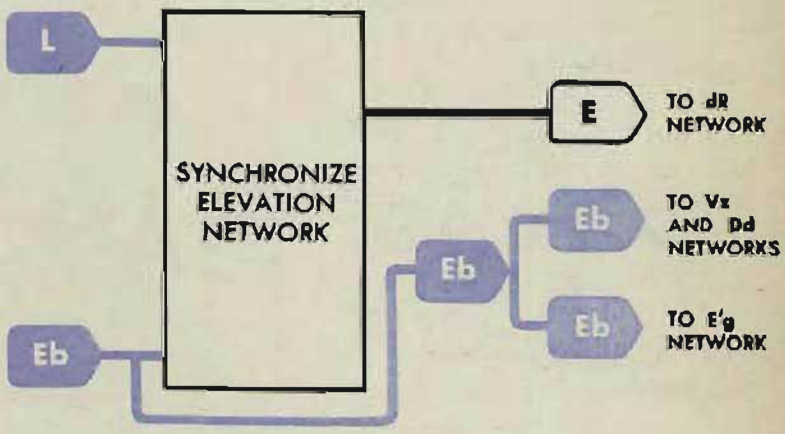
Eb Director elevation

Eb becomes an intermediate quantity when A tests are run by setting *E* into the computer with the sync *E* handcrank.

$Eb = E + L$

Eb will be in error if *E* or *L* is in error.

Eb is an input to the *Vz*, *Dd*, and *E'g* networks. Therefore, an error in *Eb* will cause errors in these quantities.



Reading Eb

There is no *Eb* dial or counter in the computer. Certain values must be set into the computer to make *Eb* equal *E* or *E'g* which can be read at the computer.

Setting Eb equal to E

Set *L* on 2000'. Set *E* on the desired value of *Eb* with the sync *E* handcrank in the CENTER position. Then put the sync *E* handcrank in the OUT position, and match the sync *E* dials at the index.

Setting Eb equal to E'g

Set *Vs* on 2000'.

Set *Vz* on zero.

Turn the sync *E* handcrank in the OUT position to set the desired value of *Eb* on the *E'g* dials.

Setting Eb with the director

Put the sync *E* handcrank in the *IN* position and match the sync *E* dials at the index. Transmit *Eb* from the director.

Several transmitted quantities are inputs to other networks, as well as final computer outputs.

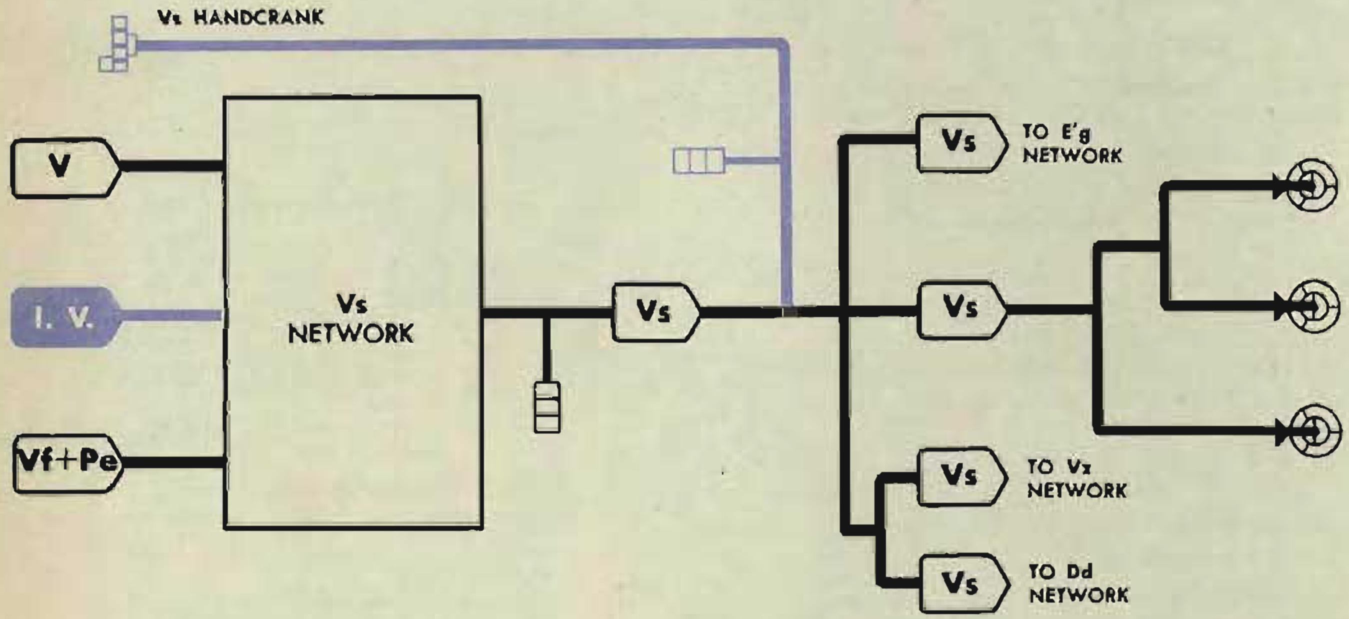
Vs Sight angle

Vs is used as an input to the *E'g*, *Vz* and *Dd* networks. Therefore an error in *Vs* will cause errors in *E'g*, *Vz*, and *Dd*.

Vs can be read to within 1' on the sight angle indicating counter at the rear of the computer or on the *Vs* master counter under cover 6. A value of 2000' is the arbitrary zero.

To set *Vs* at a desired value, push the sight angle handcrank IN, and turn it until the *Vs* counter reads that value.

To set *Vs* at computed zero, set *So*, *Sh*, *Sw*, and *dH* at 0 knots, *A*, *Br* and *Bws* at 90°, *E2* at 0°, *Vj* at 0, *Vf* + *Pe* at 0', and *Ds* at 500 mils. Set *I.V.* at 2550 f.s. and *Tf/R2* at its lower limit. Pull the sight angle handcrank *OUT* and turn the power ON. The *Vs* indicating counter should now read 2000'.



Ds Sight deflection

Ds is used as an input to the *Dd*, *Vz*, *V*, and *WrD* networks. Therefore, an error in *Ds* will cause errors in all these quantities.

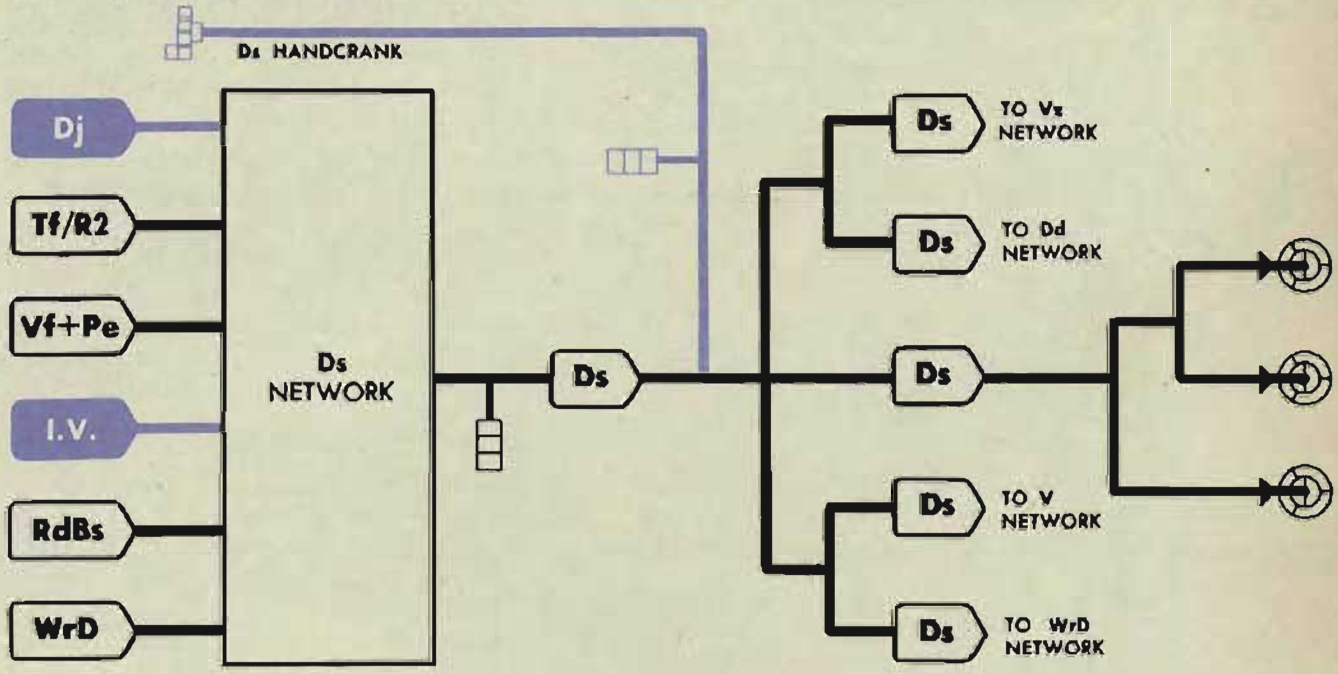
Ds can be estimated to within 0.1 mil on the *Ds* indicating counter at the rear top of the machine or on the *Ds* master counter under cover 8.

A value of 500 mils is the arbitrary zero.

Values below 000 or above 999 cannot be read directly on the *Ds* indicating counter. Such values may be read on the *Ds* master counter.

To set *Ds* at a desired value, turn the sight deflection handcrank in the IN position until the *Ds* indicating counter reads that value.

To set *Ds* at computed zero (500 mils), set *So*, *Sh*, *Sw*, *Br*, *A*, and *Dj* at zero, *Tf/R2* at its low limit, *Vf + Pe* at 100′, and *I.V.* at 2550 f.s.

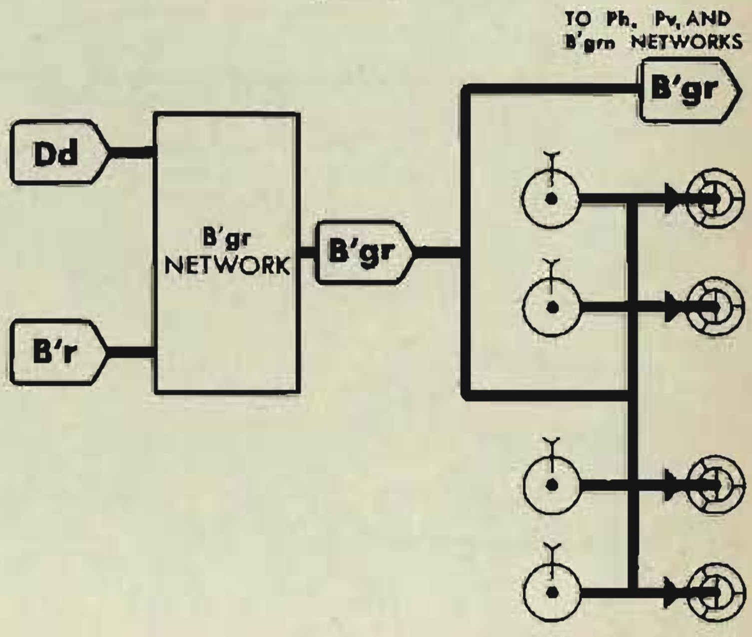


B′gr Gun train order

In computers that use *B′gr* as an input to the parallax network, an error in *B′gr* will cause errors in *Ph* and *Pv*.

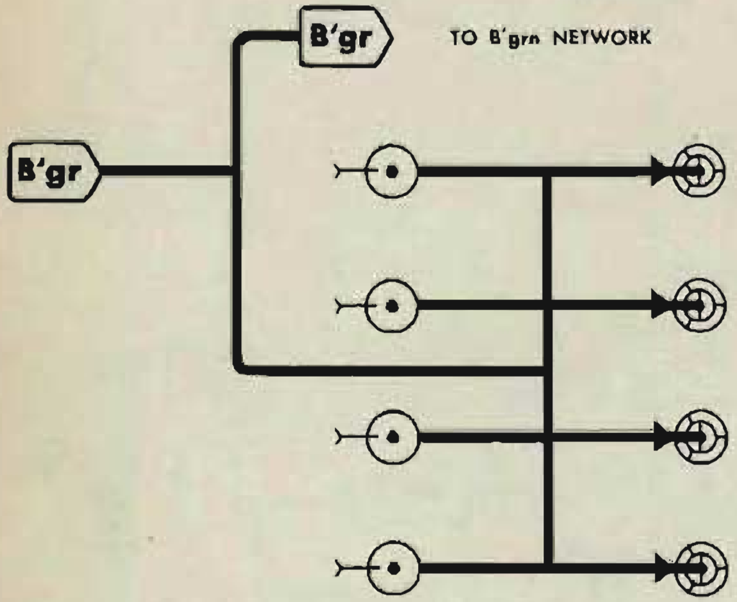
B′gr can be estimated to within 1′ on the *B′gr* automatic or indicating dials at the rear of the computer under cover 8.

To set *B′gr*, turn the control switch to LOCAL and turn the generated bearing crank in the OUT position until the *B′gr* dials read the desired value.



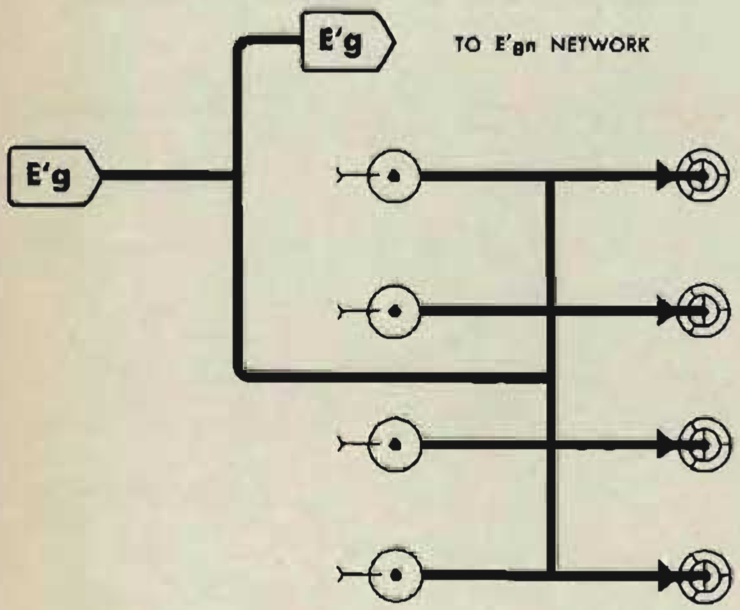
STAR SHELL INTERMEDIATE QUANTITIES

Most of the intermediate quantities used for the Computer Mark 1 A test analysis are also used during Star Shell Computer A test analysis. In addition, four of the computed quantities are inputs to the star shell computer. These additional quantities used as intermediates are:



B'gr Gun train order

B'gr is an input to the *B'grn* network. Therefore an error in *B'gr* will cause an error of equal size in *B'grn*. See page 103 for reading and setting *B'gr*.

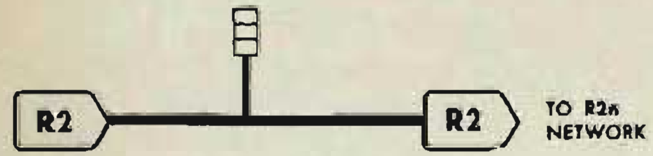


E'g Gun elevation order

E'g is an input to the *E'gn* network. Therefore, an error in *E'g* will cause an error of equal size in *E'gn*.

E'g can be estimated to within 1' on the *E'g* dials to the rear of the computer.

To set *E'g* at a desired value, turn the sync *E* handcrank in the OUT position until the *E'g* dials read that value.

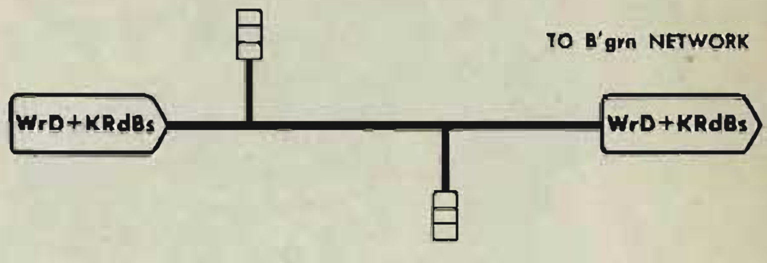


R2 Advance range

R2 is an input to the *R2n* network. Therefore an error in *R2* will cause an error of equal size in *R2n*. See page 94 for reading and setting *R2*.

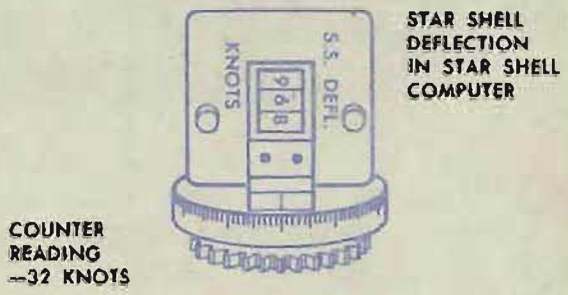
WrD + KRdBs Star shell deflection

WrD + KRdBs will be in error if *WrD* or *RdBs* is in error. *WrD + KRdBs* is an input to the *B'grn* network. Therefore an error in *WrD + KRdBs* will cause an error in *B'grn*.



Reading WrD + KRdBs

WrD + KRdBs can be read to within one knot on the star shell deflection counters under computer cover 3 and the rear cover of the star shell computer.



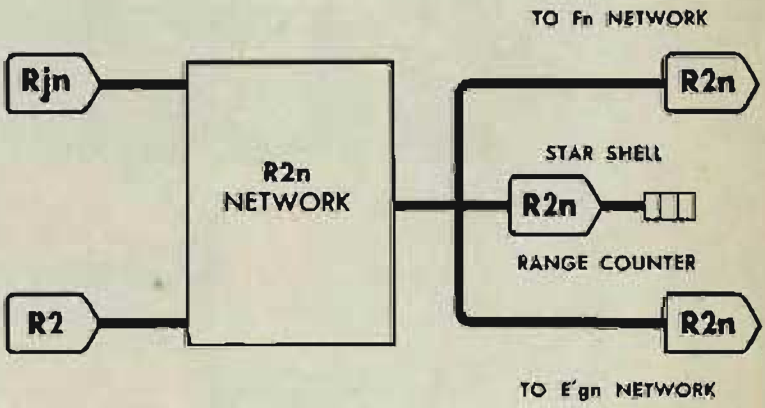
Setting WrD + KRdBs

To set *WrD + KRdBs* at a desired value, disconnect power leads 1G and 1GG on the *WrD + KRdBs* follow-up and turn the output gearing by hand until the star shell deflection counter reads that value. Then wedge the follow-up output gearing.

ALTERNATE SETTING: Set *Sh* at 200 knots.
Turn *A* from 0° until the star shell deflection counter reads the desired value.

R2n Star shell range

R2n is an intermediate quantity within the star shell computer.
R2n = R2 + K + Rjn
R2n will be in error if *R2* or *Rjn* is in error. *R2n* is an input to the *Fn*, *B'grn*, and *E'gn* networks. Therefore an error in *R2n* will cause errors in these quantities.

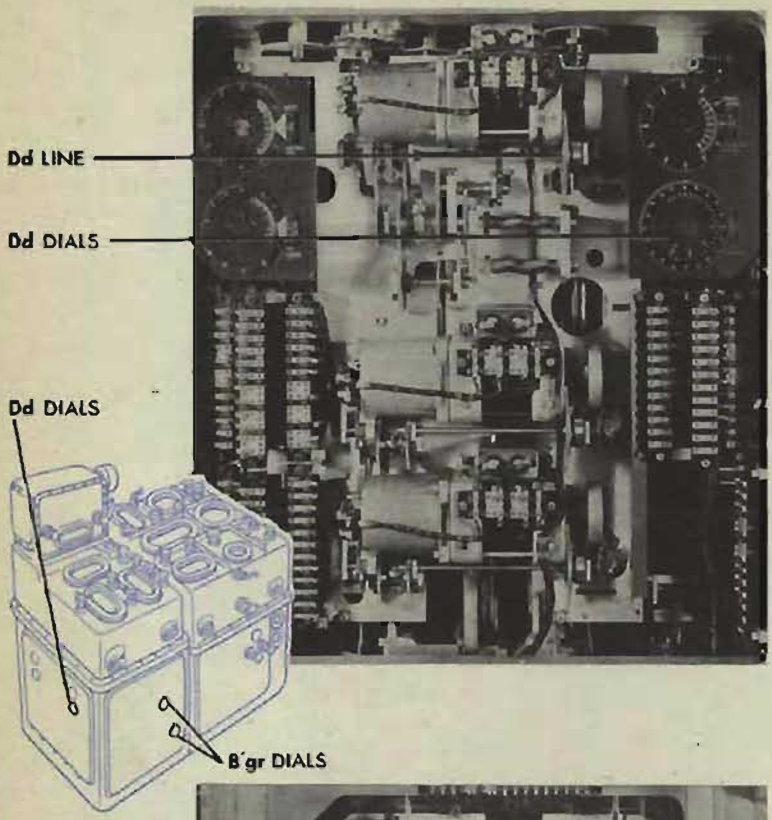


Reading R2n

R2n can be read to within 10 yards on the star shell range counter at the front of the star shell computer.

Setting R2n

To set *R2n*, turn *cR* with the power ON, until the star shell range counter reads the desired value.

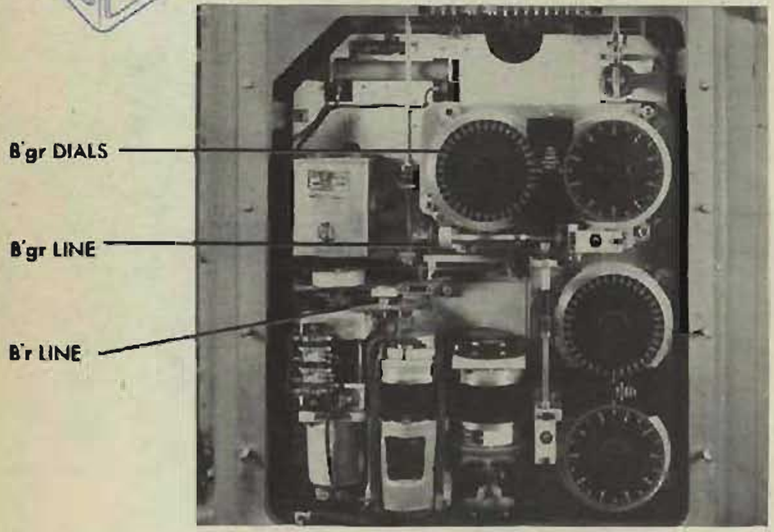


ERRORS IN B'gr

$B'gr = Dd + B'r$

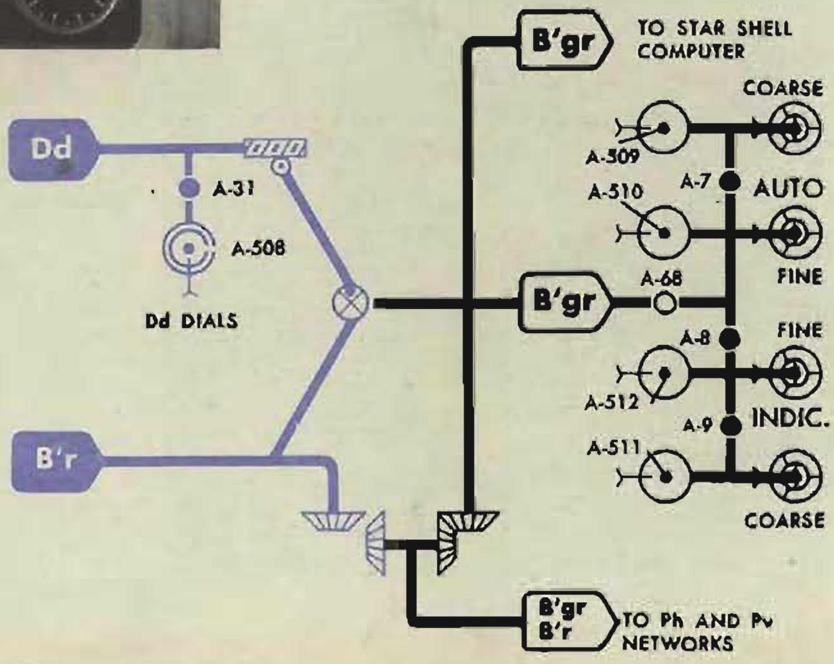
If the $B'gr$ transmitters have been removed and reinstalled, check A-68 and A-8.

Check the Dd input by comparing the reading on the Dd dials with the value given on the problem results form. If the Dd dial reading does not agree with the value given, check the Dd network; see page 117.



Check the $B'r$ input by checking the problem setup values on the stable element dials. If $B'gr$ is still incorrect, check A-602.

If both inputs are correct, check A-68, A-8, A-9, and A-7.



ERRORS IN E′g

$E'g = Vs - Vz + Eb$

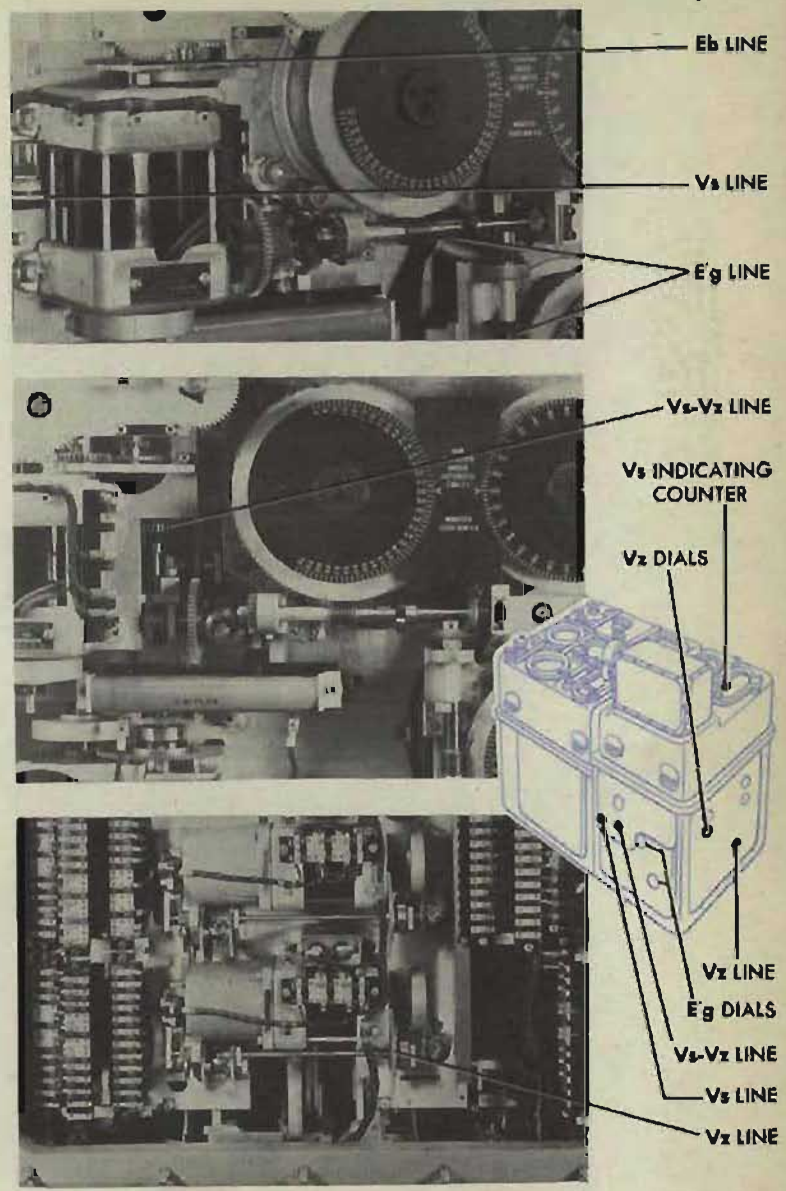
If the *E′g* transmitters have been removed and reinstalled, check A-51 and A-5.

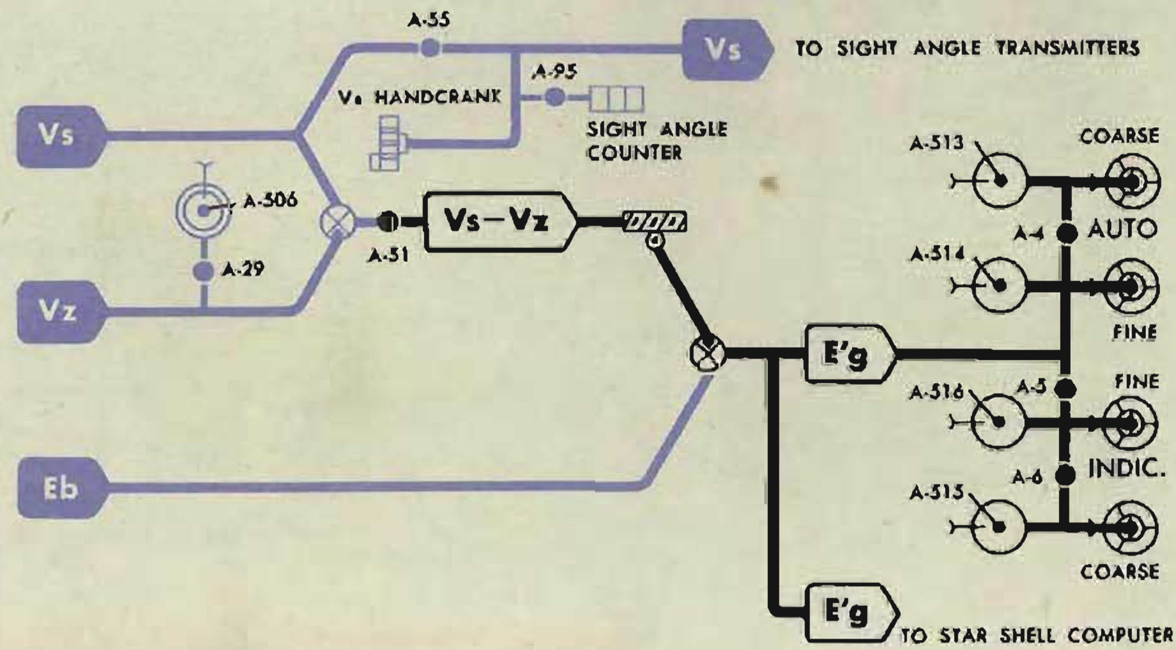
Check the *Vs* input by comparing the reading on the *Vs* indicating counter with the value given on the problem results form. If the *Vs* counter reading does not agree with the value given, check the *Vs* network; see page 108.

Check the *Vz* input by comparing the reading on the *Vz* dial with the value given on the problem results form. If the *Vz* dial reading does not agree with the value given, check the *Vz* network; see page 119.

Check the *Eb* input by checking the synchronize elevation network; see page 132.

If all three network inputs are correct, check A-51, A-5, A-6, and A-4.





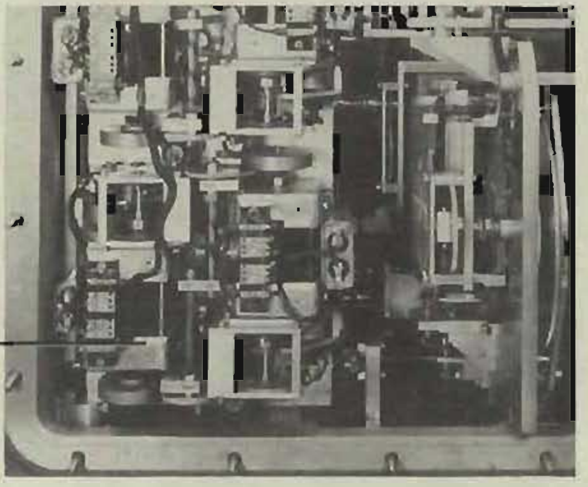
ERRORS IN Vs

$Vs = V + Vl + Pe + Vfm$

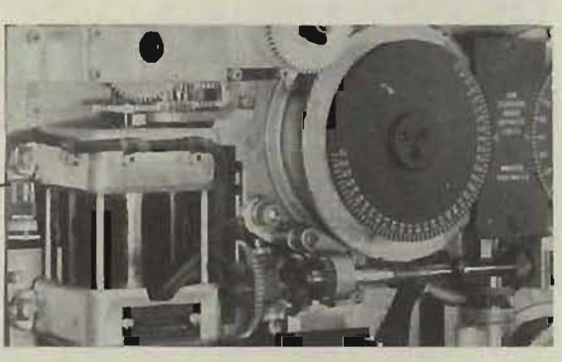
Check the *V* follow-up.

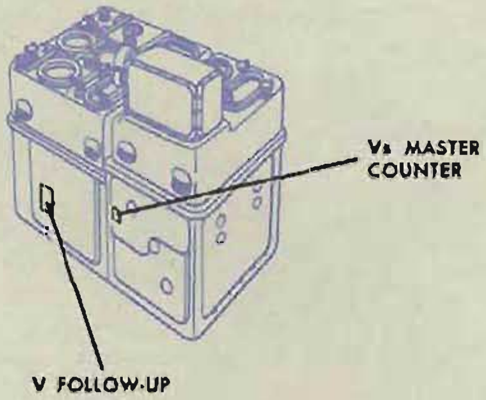
Check the reading on the *Vs* indicating counter against the reading on the *Vs* master counter. If the counter readings do not agree, check A-55 and A-95.

V FOLLOW-UP UNDER COVER 5

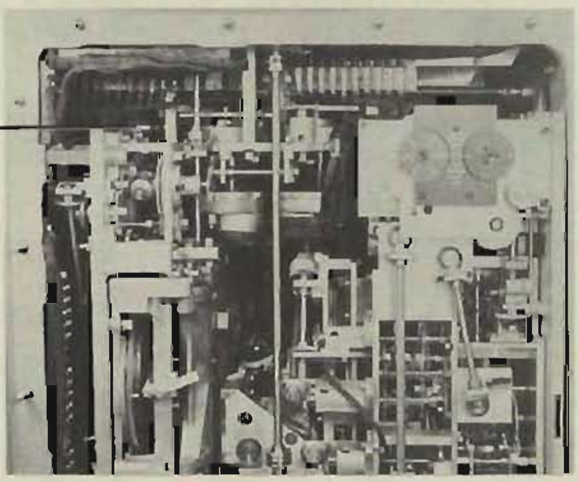


Vs MASTER COUNTER UNDER COVER 6





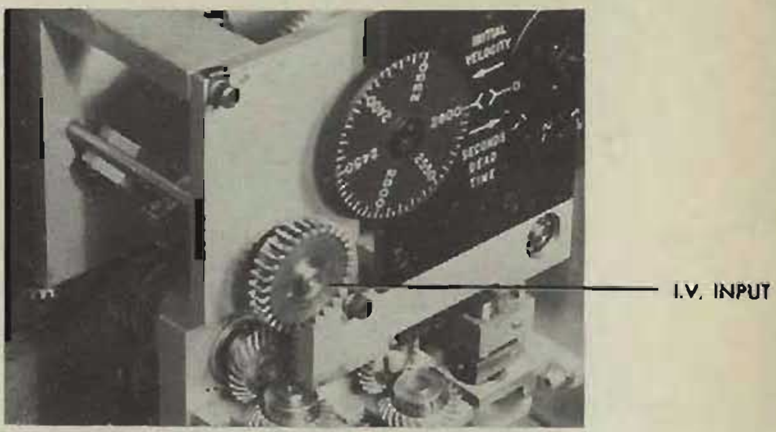
Vs LINE UNDER COVER 3

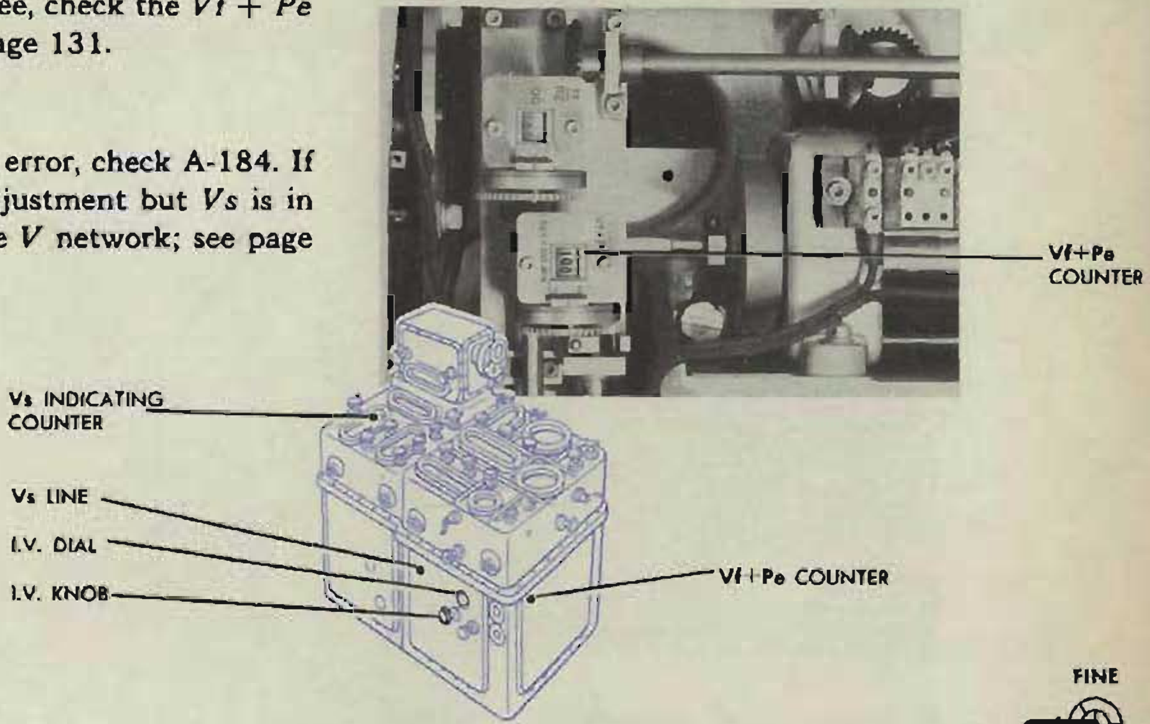


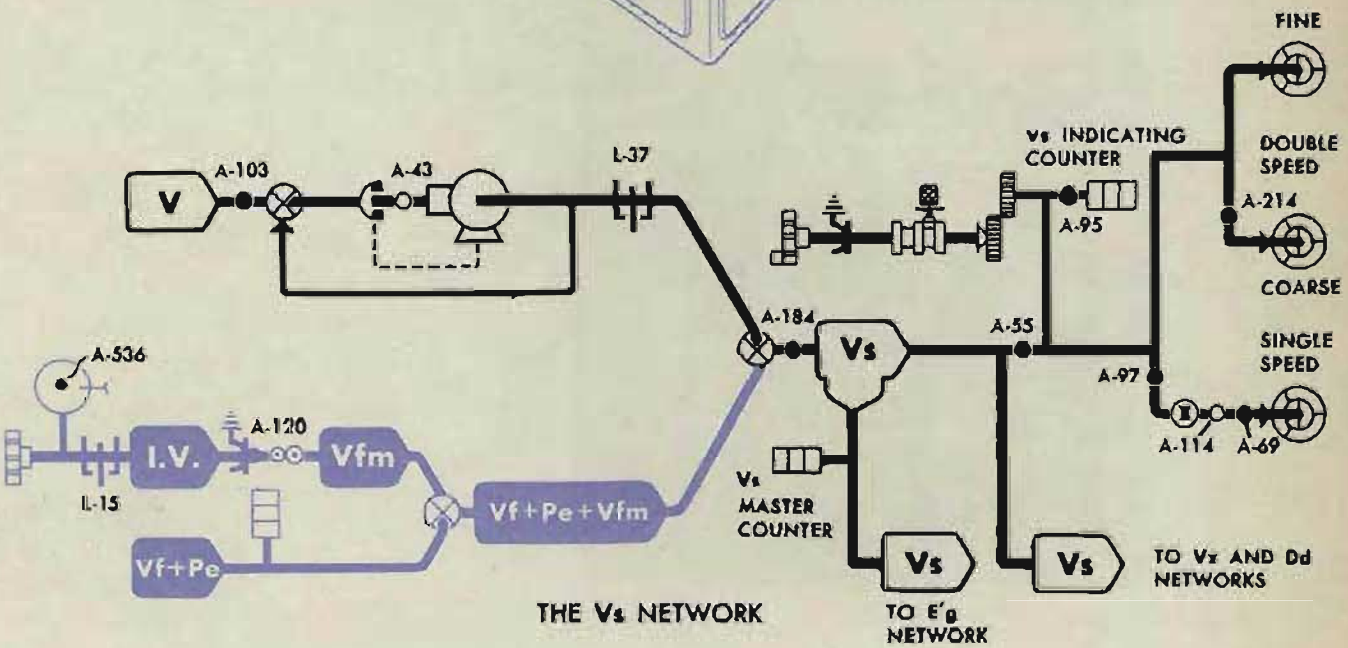
Check the *I.V.* input, by checking A-536.

Check the *Vf* + *Pe* input by comparing the reading on the *Vf* + *Pe* counter with the value given in the intermediate quantities. If the readings do not agree, check the *Vf* + *Pe* network; see page 131.

If *Vs* is still in error, check A-184. If A-184 is in adjustment but *Vs* is in error, check the *V* network; see page 126.







THE Vs NETWORK

CONTENTS

VOLUME ONE

PART ONE

TESTS

PART TWO

ANALYSIS OF TEST ERRORS

PART THREE

UNIT CHECK TESTS

PART FOUR

READJUSTMENT PROCEDURE

VOLUME TWO

PART FIVE

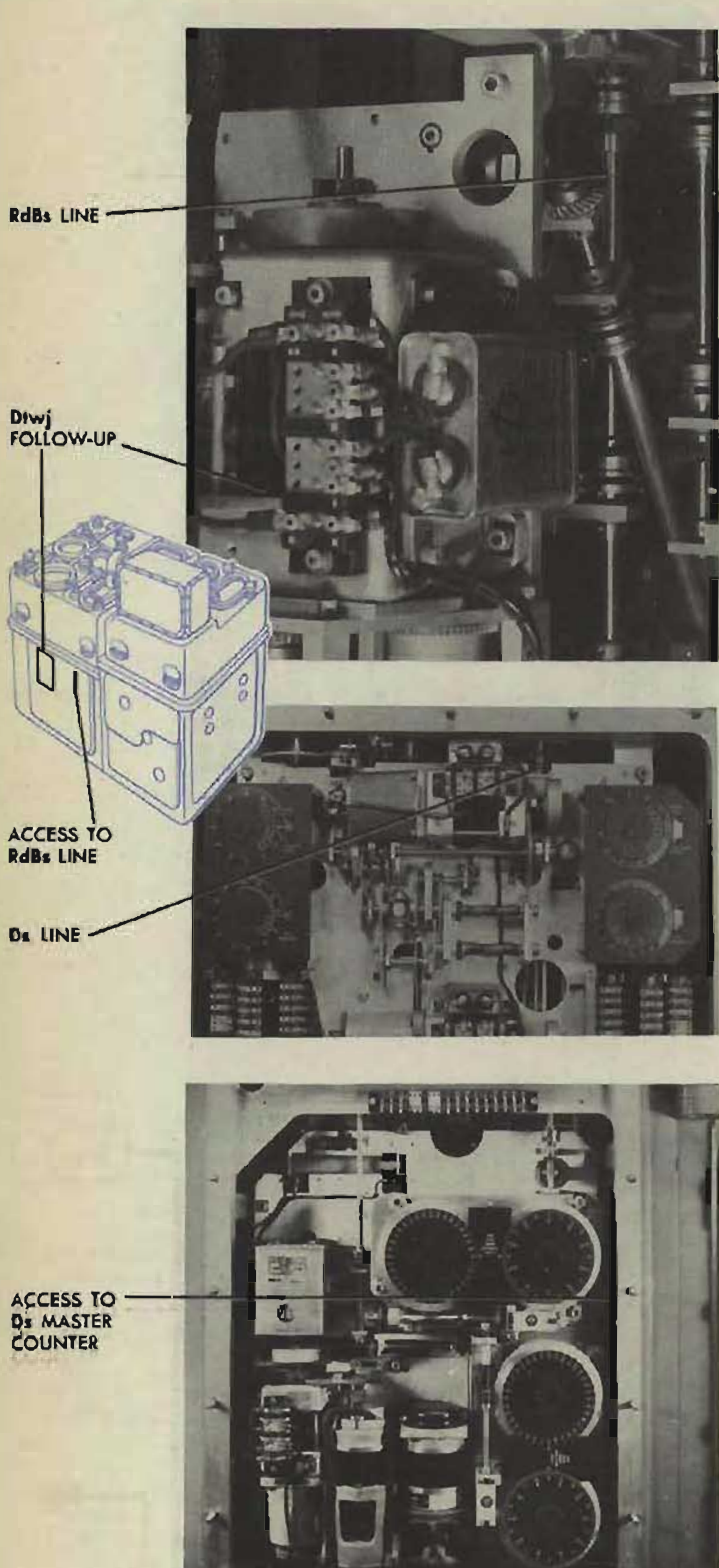
PART SIX

PART SEVEN

REMOVAL OF MECHANISMS

PART EIGHT

PART NINE



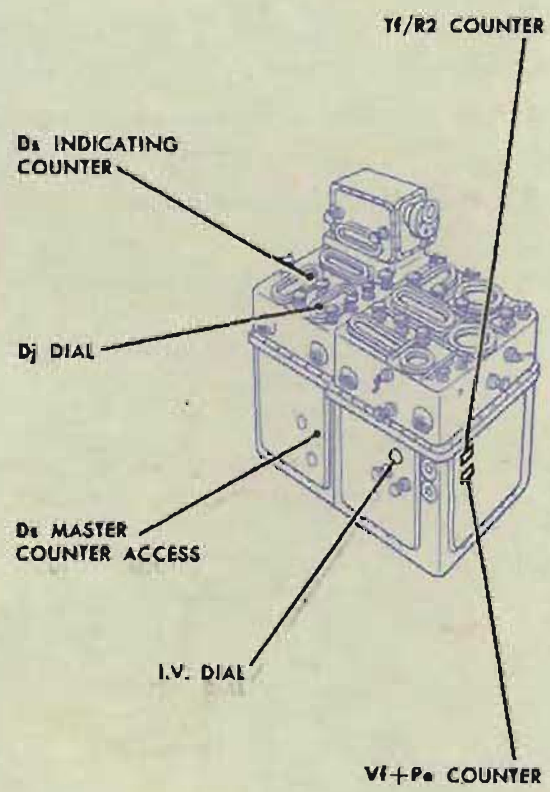
ERRORS IN Ds

Ds = Dtwj − Dfs

Check the *Dtwj* follow-up.

Check the *Ds* counters.

If the *Ds* indicating counter reading does not agree with the *Ds* master counter reading, check A-89 and A-94.



Checking the network inputs

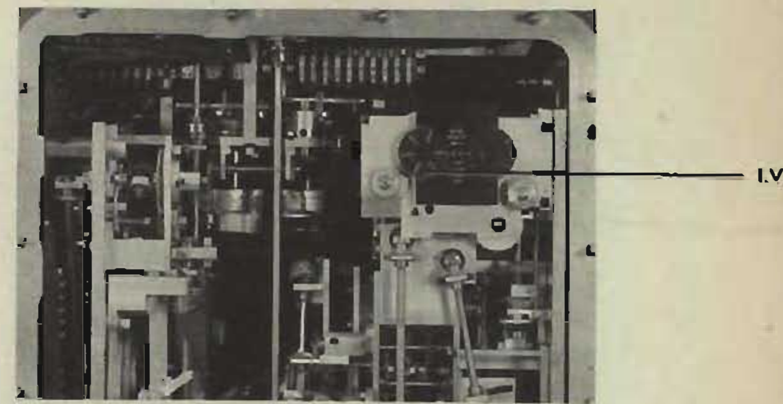
Check the *I.V.* input by checking A-536.

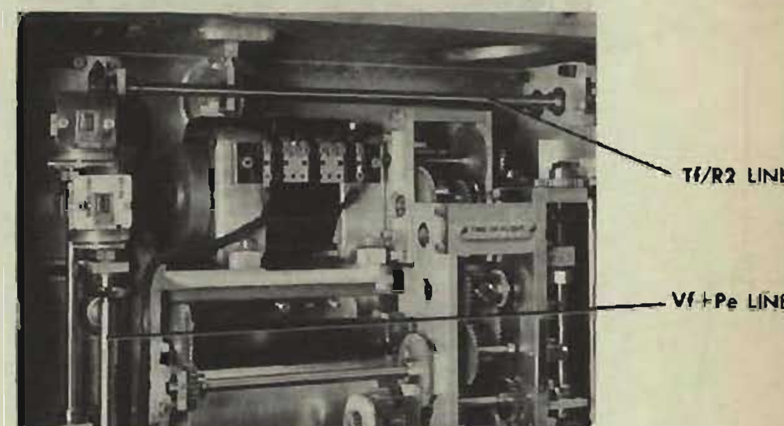
Check the *Vf + Pe* input by comparing the reading on the *Vf + Pe* counter with the value given in the intermediate quantities. If the readings do not agree, check the *Vf + Pe* network; see page 131.

Check the *Tf/R2* input by comparing the reading on the *Tf/R2* counter with the value given in the intermediate quantities. If the readings do not agree, check the *Tf/R2* network; see page 130. Check the Dj input by checking A-500.

Check the *RdBs* input; see page 137.

Check the *WrD* input; see page 138.





Checking the network

When the network inputs are correct, but *Ds* is in error:

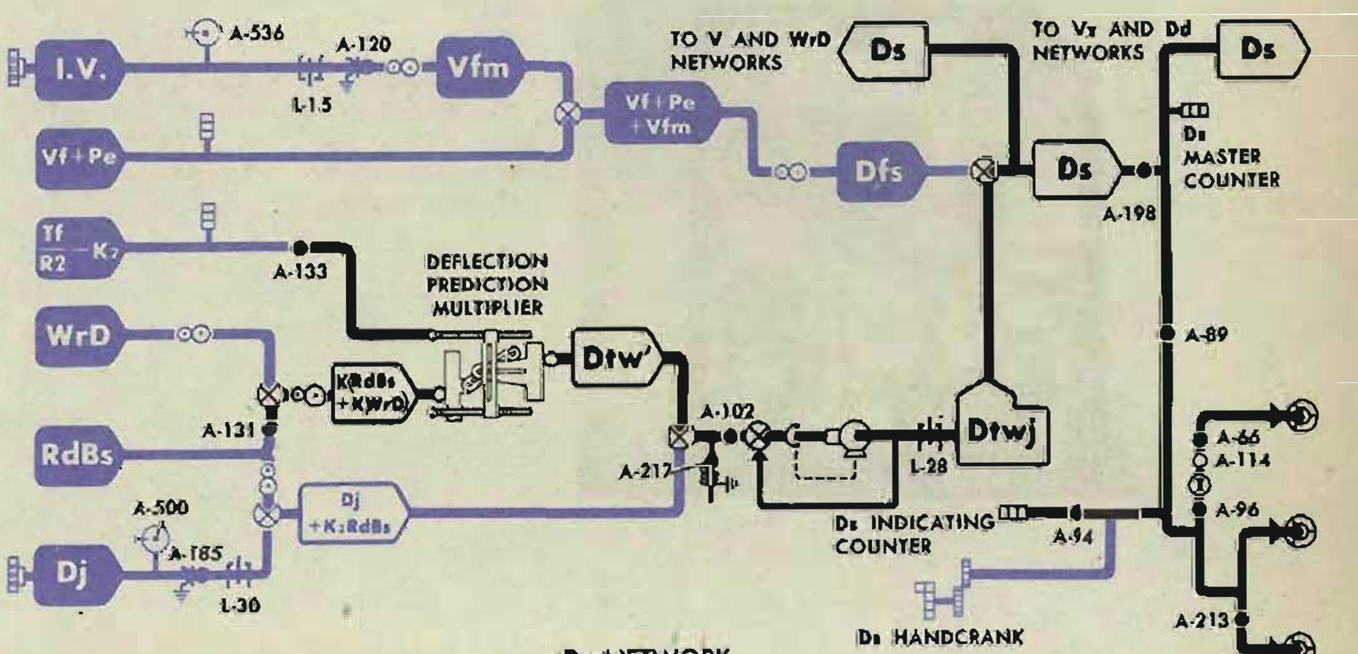
Make the unit check test of the deflection prediction multiplier.

The check test may indicate an error in one of the inputs of the multiplier.

1 If the lead screw is incorrectly positioned, check A-133.

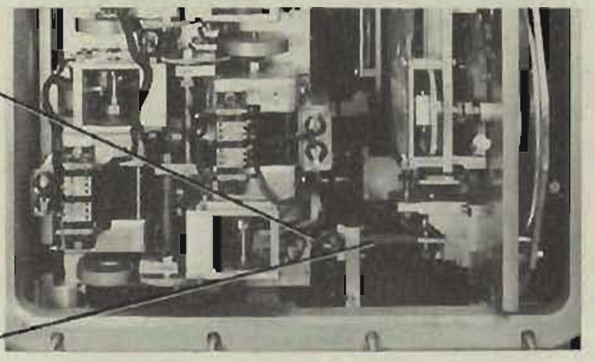
2 If the rack is incorrectly positioned, check A-131.

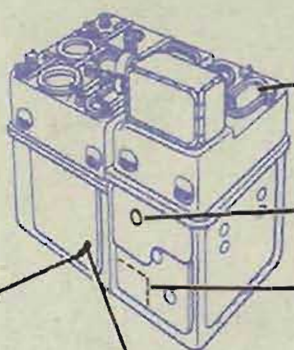
When all the inputs are correct, check A-198 and A-102.

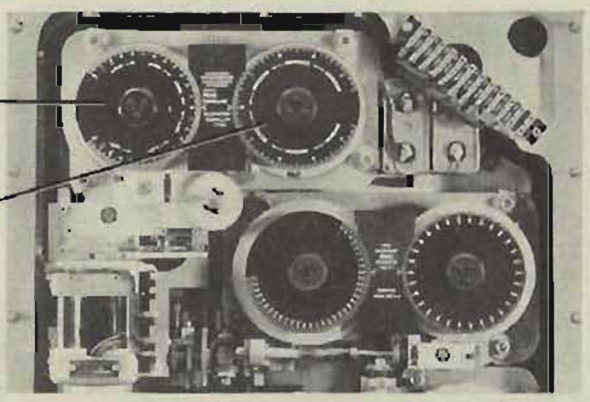


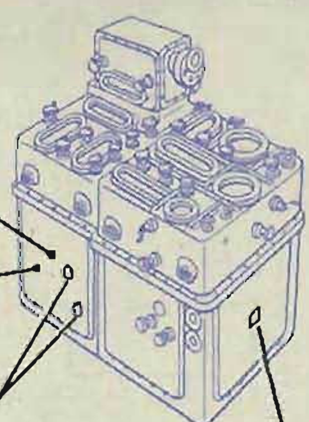
Ds NETWORK

ERRORS IN Ph AND Pv









Checking the network inputs

Check the *R2* input by comparing the reading on the *R2* indicating counter with the value given on the problem results form. If the *R2* reading does not agree with the *R2* value given, check the *R2* network; see page 122.

Check the *E2* input by comparing the reading on the *E2* master counter with the value given in the intermediate quantities. If the *E2* reading does not agree with the *E2* value given, check the *E2* network; see page 124.

If *B'gr* is the input to the parallax component solver, check the value by comparing the reading on the *B'gr* dials with the value given on the problem results form. If *B'gr* is in error, check the *B'gr* network; see page 106.

If *B'r* is the input to the parallax component solver, check the problem set-up value on the stable element dials.

Check the *L* input by checking A-58, A-28, and A-505.

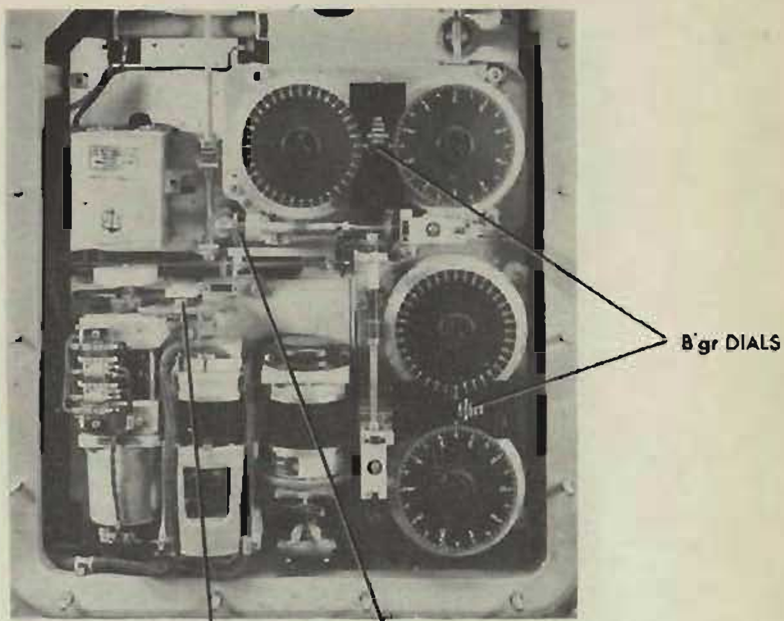
Checking the network

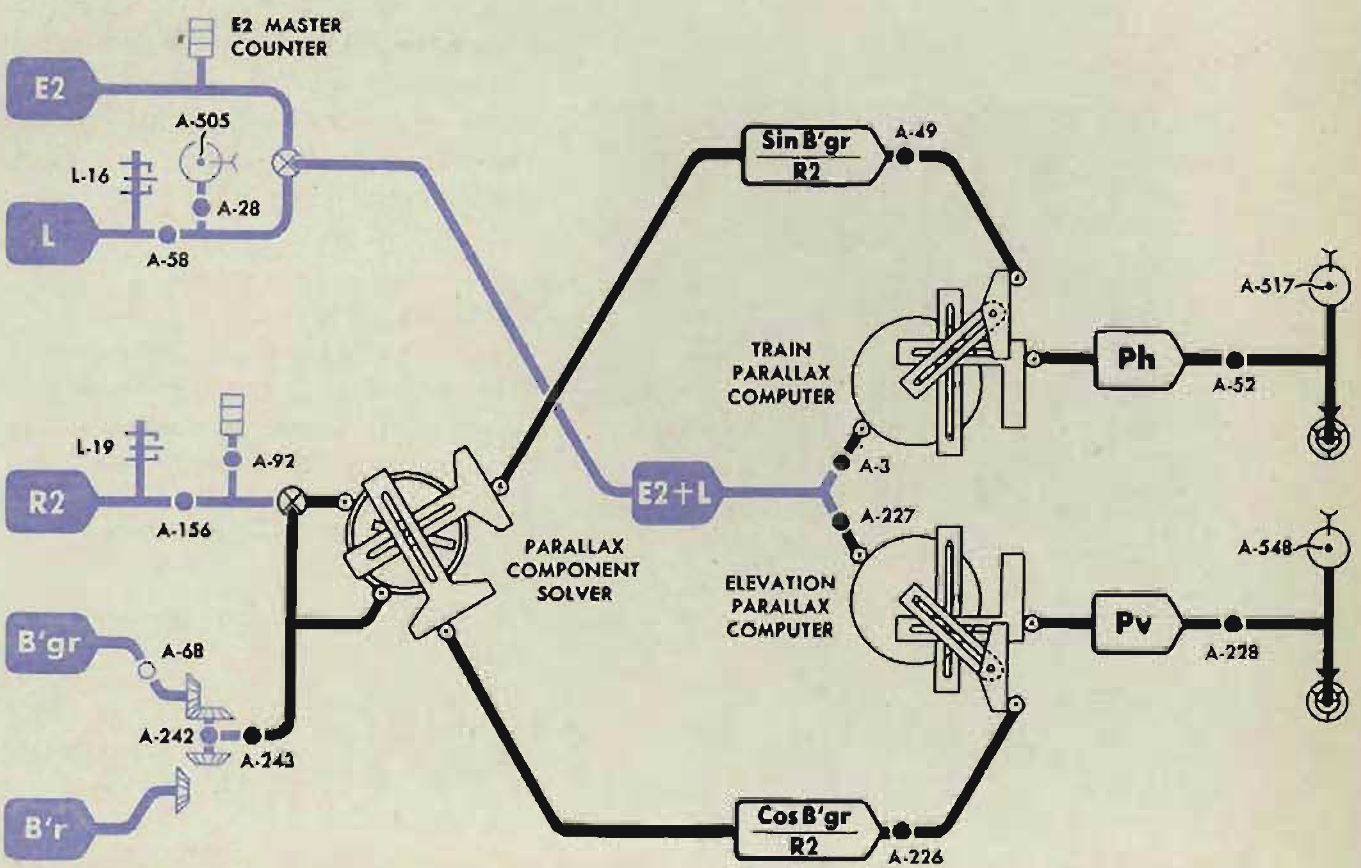
When the network inputs are correct but *Ph* is in error, run the unit check test of the parallax section. The unit check test will indicate errors in the inputs to the parallax component solver or the train parallax computer. If there are errors in the parallax component solver, check A-156, A-242, and A-243.

If there are errors in the train parallax computer, check A-49 and A-3. If the unit inputs are correct, check A-52 and A-517.

When the network inputs are correct but *Pv* is in error, run the unit check test of the parallax section. The unit check test will indicate errors in the inputs to the parallax component solver or the elevation parallax computer. If there are errors in the parallax component solver, check A-156 and A-243. If there are errors in the elevation parallax computer, check A-226 and A-227.

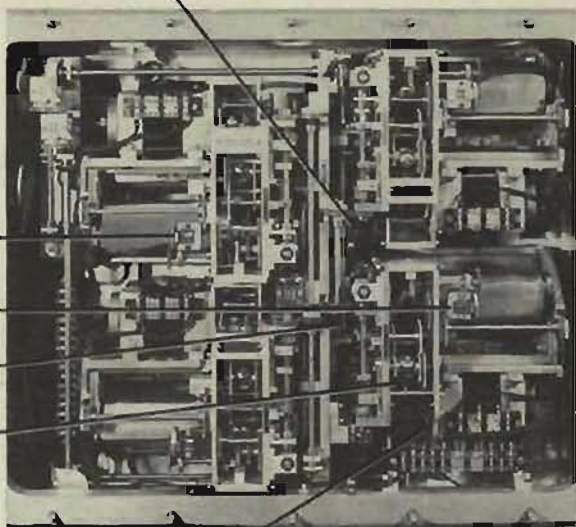
If the unit inputs are correct, check A-228 and A-548.





ERRORS IN FUZE

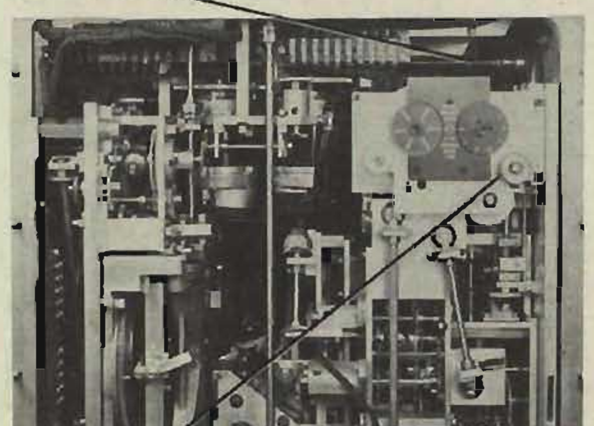
Serial Nos. 780 and lower



$F = f\,(E2, R3)$ where $R3 = R2 + RTg$,
and $RTg = dR \cdot Tg$

Check the fuze follow-up.

Check A-77.



Checking the network inputs

Check the $E2$ input by comparing the $E2$ master counter reading with the $E2$ intermediate quantity. If the counter reading is incorrect, check the $E2$ network; see page 124.

Check the $R2$ input by comparing the $R2$ counter reading with the value given on the problem results form. If the counter reading is incorrect, check the $R2$ network; see page 122.

Check the dR input by comparing the dR dial reading with the dR intermediate quantity. If the dial reading is incorrect, or cannot be read accurately, check the dR network; see page 134.

Check the Tg input by checking A-535.

Checking the network

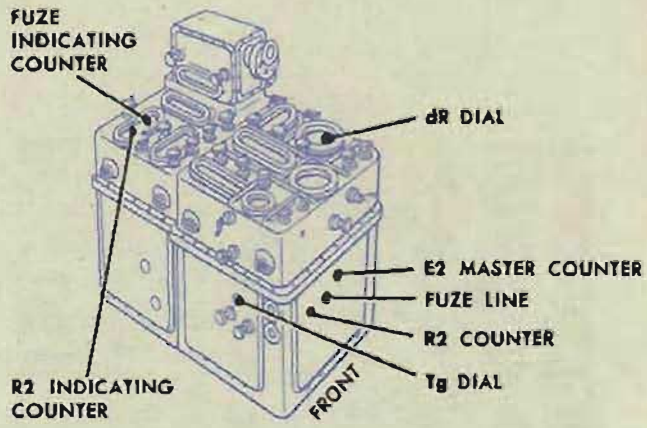
When the network inputs are correct but fuze is in error:

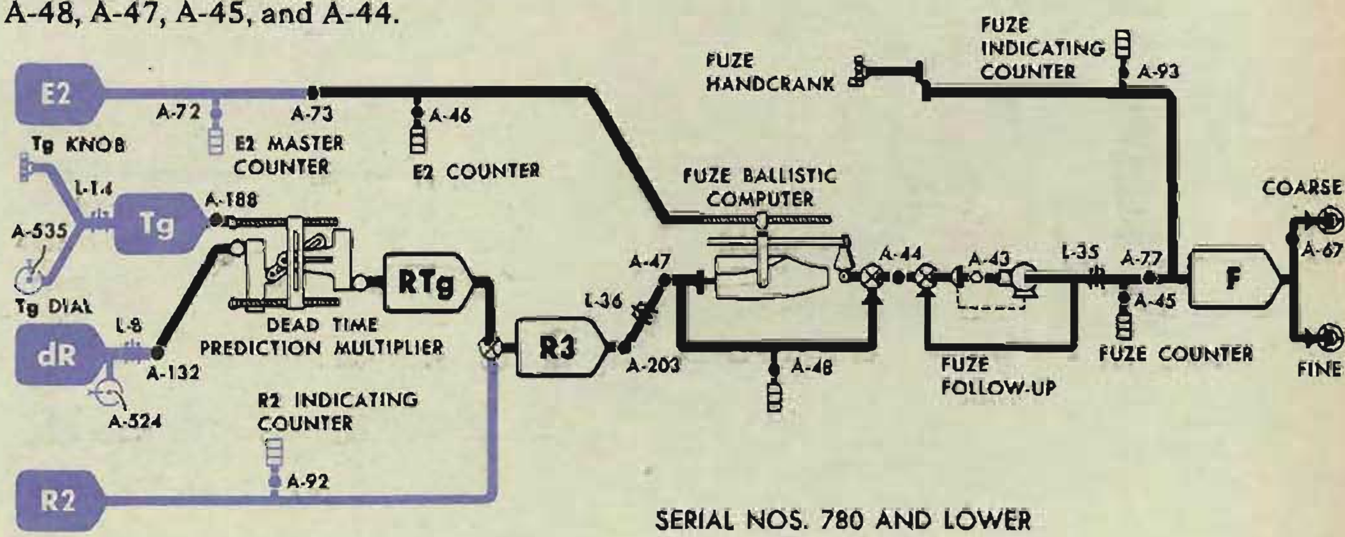
Check the *E2* counter in the fuze ballistic computer against the *E2* master counter. If the readings differ, check A-73.

Check the reading on the *R3* counter against the *R3* intermediate quantity.

If the *R3* reading does not agree with the value given, make the dead time prediction multiplier check test; see page 206. If multiplier errors are indicated, check A-188 and A-132. Check A-203.

If the *R3* and *E2* counter readings are correct and the fuze ballistic counter reading is in error, run the unit check test of the fuze ballistic computer. If the unit check test indicates error in the ballistic computer, check A-46, A-48, A-47, A-45, and A-44.





SERIAL NOS. 780 AND LOWER

Serial Nos. 781 and higher

$F = f\ (E2, R3)$ where $R3 = R2 + RTg$,
and $RTg = (dRs - dRm)\ (Tg + F - Tf)$

Check the fuze follow-up.

Check A-77.

Checking the network inputs

Check the *E2* input by comparing the *E2* master counter reading with the value given in the intermediate quantities. If the counter reading is incorrect, check the *E2* network; see page 124.

Check the *R2* input by comparing the *R2* counter reading with the value given on the problem results form. If the counter reading is incorrect, check the *R2* network; see page 122.

Check the *Tg* input by checking A-535.

Check the *I.V.* input by checking A-536.

Check the *Tf* input by comparing the *Tf* master counter reading with the value given in the intermediate quantities. If the counter reading is incorrect, check the *Tf* network; see page 129.

Check the *dRs* input by first checking *dR*. Compare the *dR* dial reading with the value given in the intermediate quantities. If the dial reading is incorrect, or cannot be determined accurately, check the *dR* network; see page 134. If *dR* is correct, check A-181.

Checking the network

When the network inputs are correct but fuze is in error:

Check the *E2* counter in the fuze ballistic computer against the *E2* master counter. If the readings differ, check A-73.

Check A-262.

Make the dead time prediction multiplier check test; see page 206. If multiplier errors are indicated, check A-188 and A-132.

Check A-203.

Make the unit check test of the fuze ballistic computer. If this test indicates errors in the ballistic computer, check A-46, A-48, A-45, A-47, and A-44.

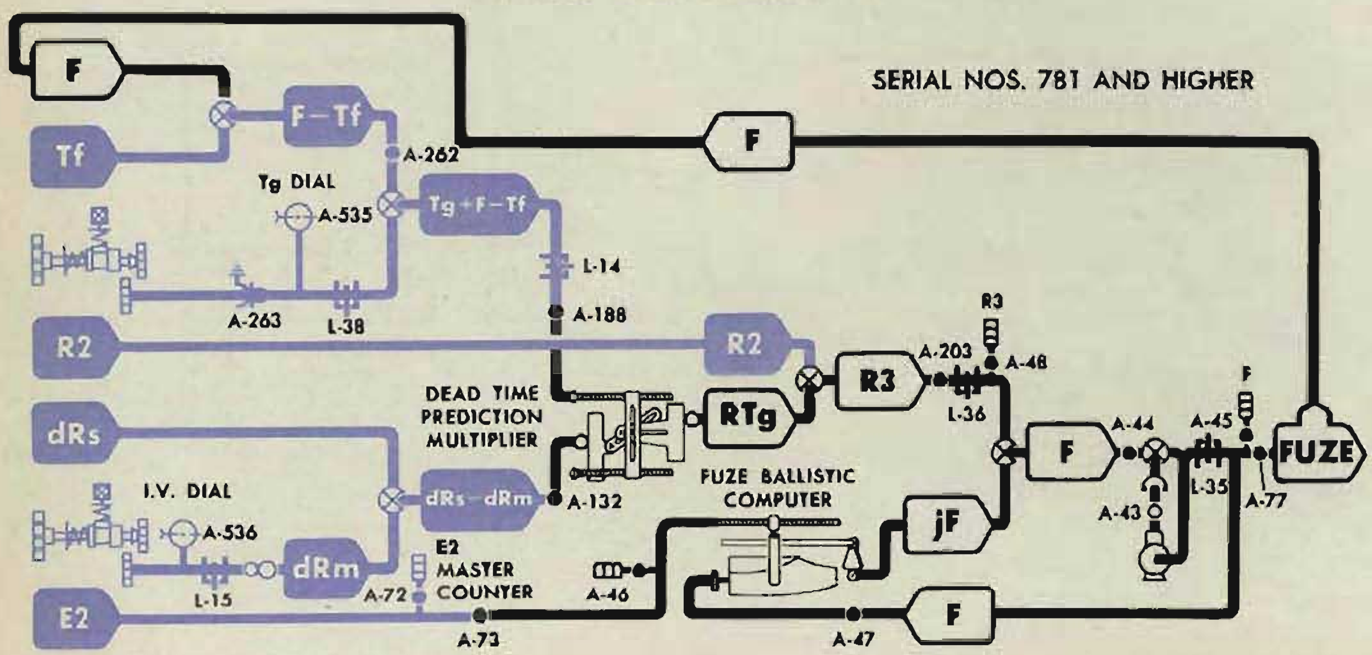


Table of Contents

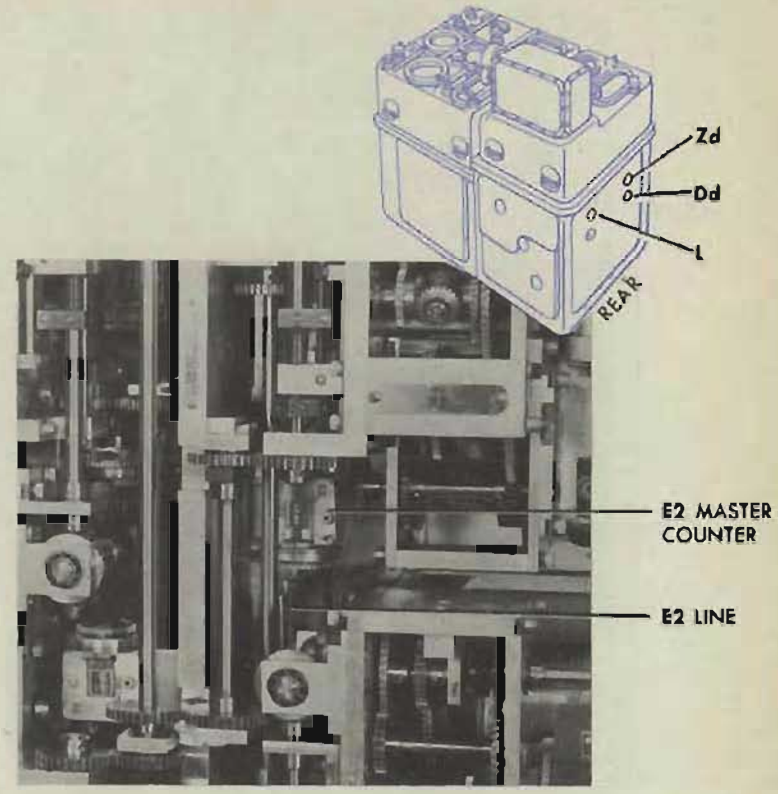
CHECKING THE Dd NETWORK

$Dd = jDd + Dz$

Check the *Dd* follow-up.

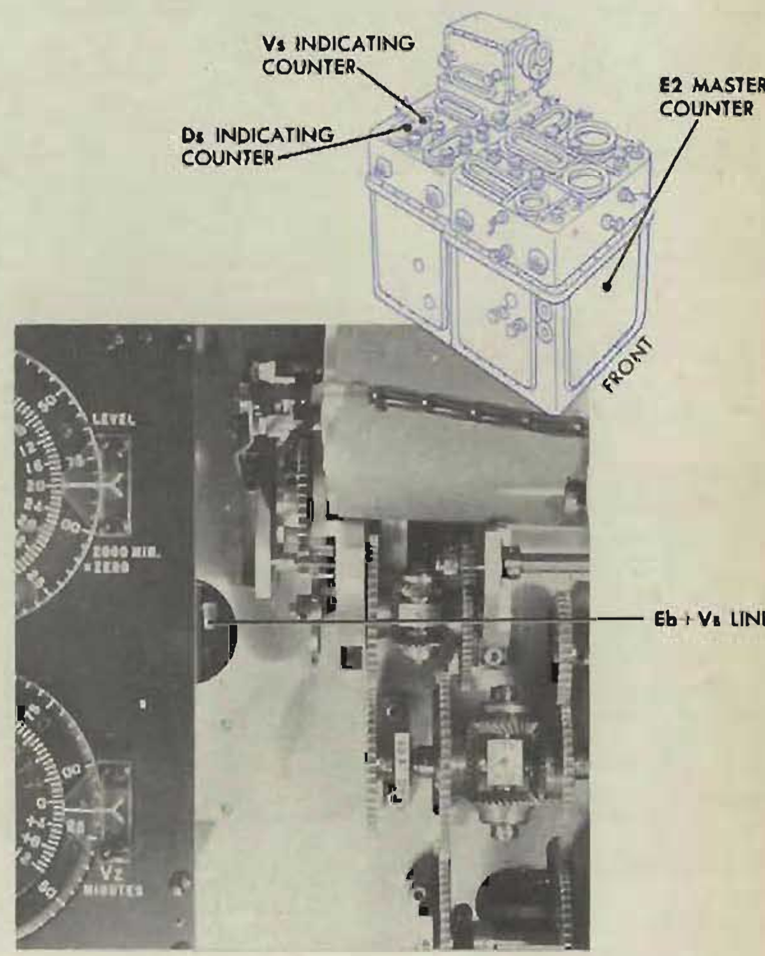
Checking the network inputs

Check the *E2* input by comparing the reading on the *E2* master counter with the value given on the problem results form. If the *E2* counter reading does not agree with the value given, check the *E2* network; see page 124.



Check the *Ds* input by comparing the reading on the *Ds* indicating counter with the value given on the problem results form. If the *Ds* counter reading does not agree with the value given, check the *Ds* network; see page 110.

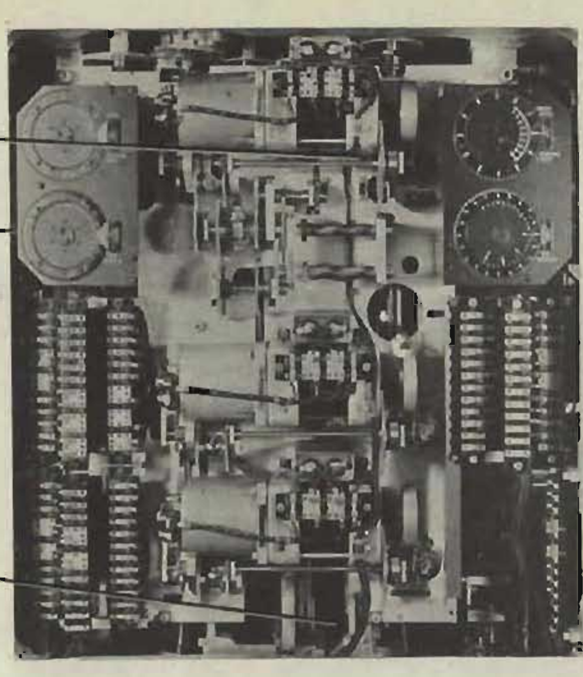
Check the *Vs* input by comparing the reading on the *Vs* indicating counter with the value given on the problem results form. If the *Vs* counter reading does not agree with the value given, check the *Vs* network; see page 108.



Check the *L* input by checking A-58, A-28 and A-505.

Check the *Eb* input by checking the synchronize elevation network; see page 132.

Check the *Zd* input by checking A-30, A-507, and A-112.



If the network inputs are correct, make the check test of the trunnion tilt section.

The check test will indicate errors in the inputs to the trunnion tilt units. One of the following may be incorrectly positioned:

The *Zd* vector of the *Dz* computer. Check A-35.

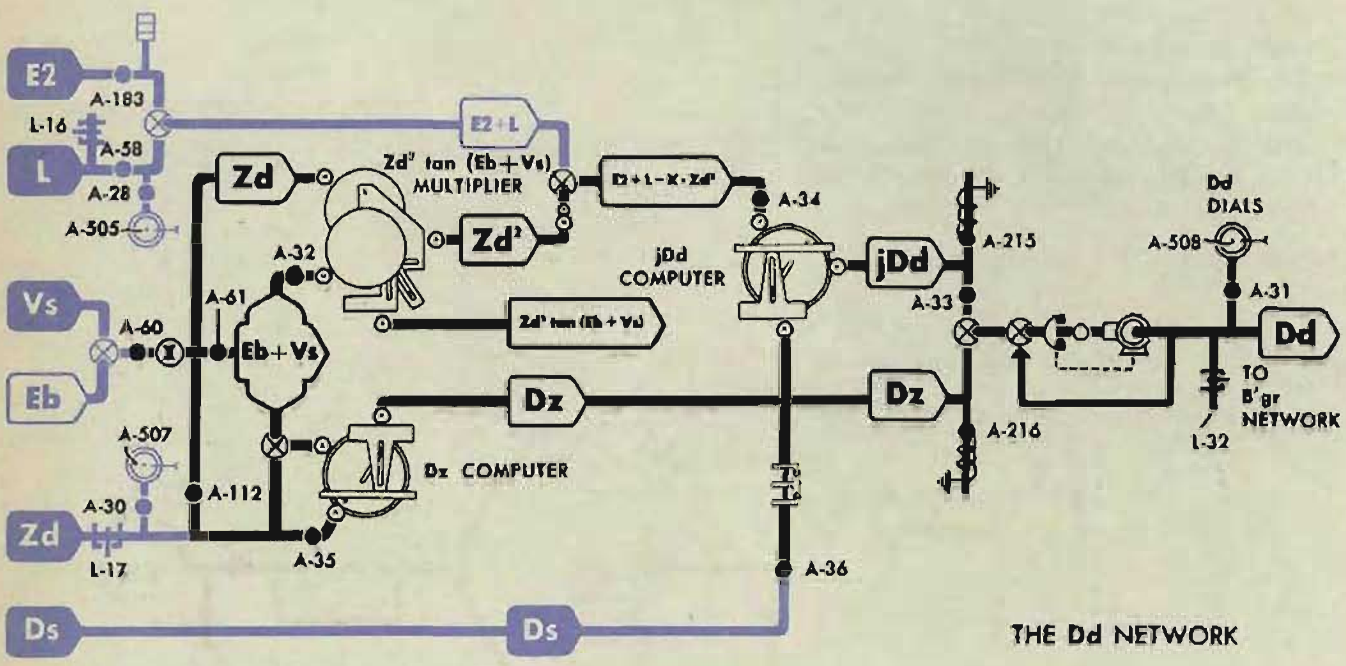
The *Eb* + *Vs* cam of the *Dz* computer. Check A-60 and A-61.

The *Ds* rack of the *jDd* computer. Check A-36.

The *E2* + *L* – *KZd*² cam of the *jDd* computer. Check A-34.

If the unit inputs are correct, check A-33, A-31, and A-508.

If any adjustments are altered, check the take-up springs A-215 and A-216.



THE Dd NETWORK

CHECKING THE Vz NETWORK

$Vz = [Zd^2 \tan(Eb + Vs)] + (Zd \cdot Ds)$

Check the Vz follow-up.

Check the Ds input by comparing the Ds indicating counter reading with the Ds value given on the problem results form. If the Ds counter reading does not agree with the value given, see page 110.

Check the Vs input by comparing the Vs indicating counter reading with the Vs value given on the problem results form. If the counter reading does not agree with the value given, see page 108.

Check the Zd input by checking A-30 and A-507.

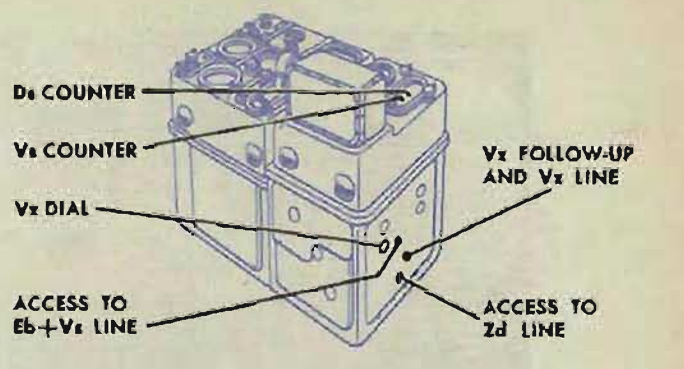
Check the Eb input by checking the synchronize elevation network; see page 132.

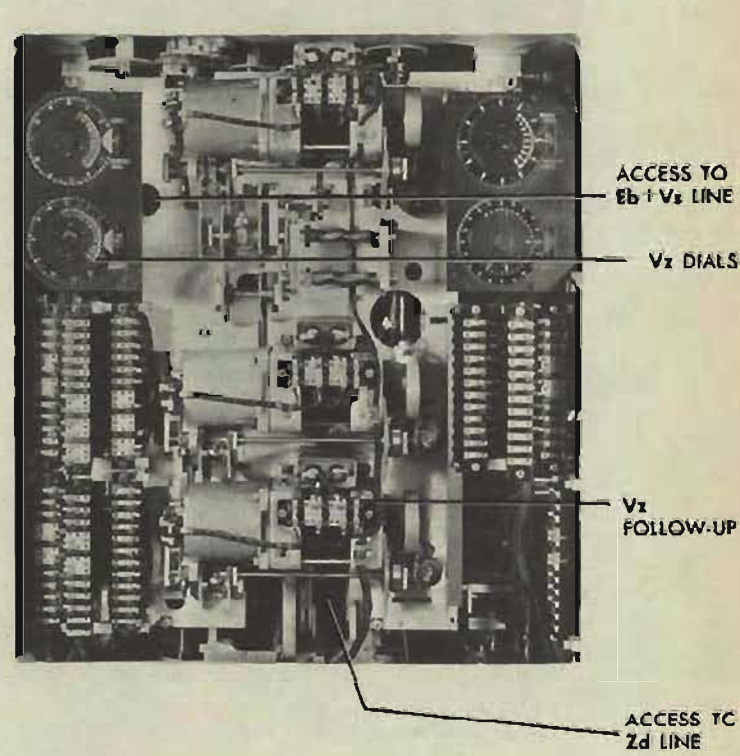
When all the inputs are correct but Vz is in error, run the unit check test of the trunnion tilt section.

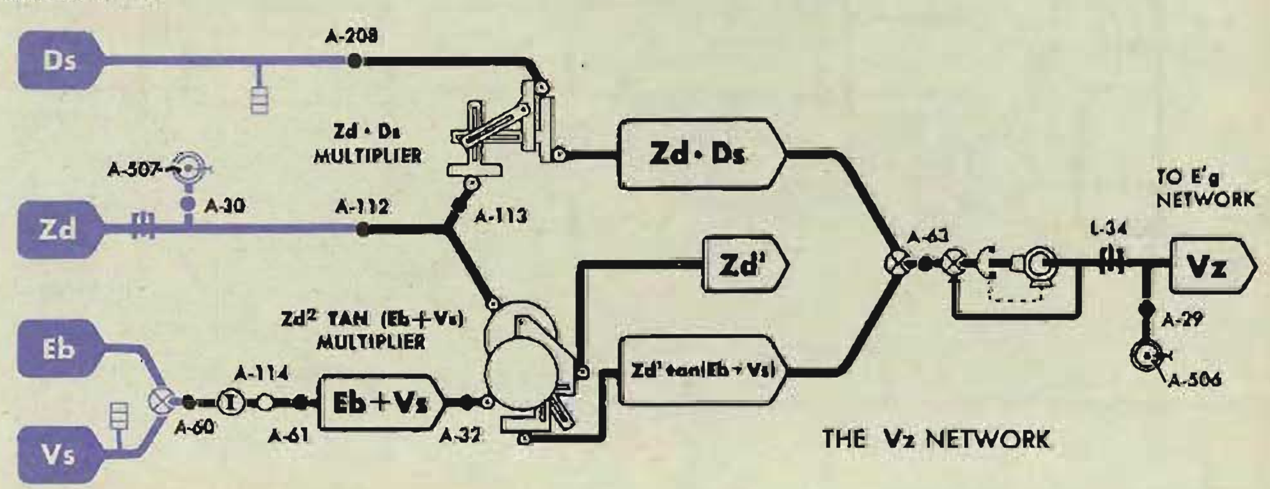
The unit check test will indicate errors in the inputs to the multipliers. Any of the following may be incorrectly positioned:

The Zd rack of the $Zd \cdot Ds$ multiplier or the Zd input to the square cam of the $Zd^2 \tan(Eb + Vs)$ multiplier. Check A-112 and A-113.
The Ds rack of the $Zd \cdot Ds$ multiplier. Check A-208.
The $Eb + Vs$ cam of the $Zd^2 \tan(Eb + Vs)$ multiplier. Check A-60, A-61 and A-32.

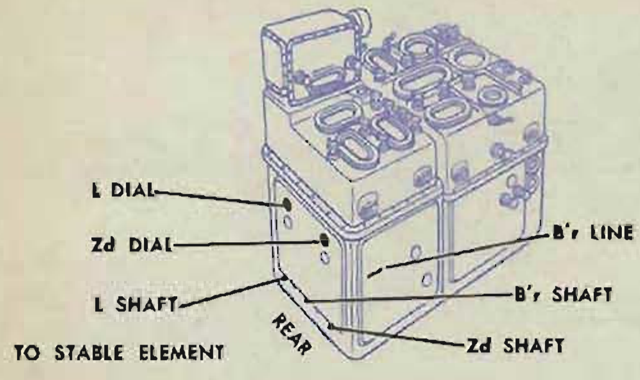
If Vz is still in error, check A-63, A-29, and A-506.

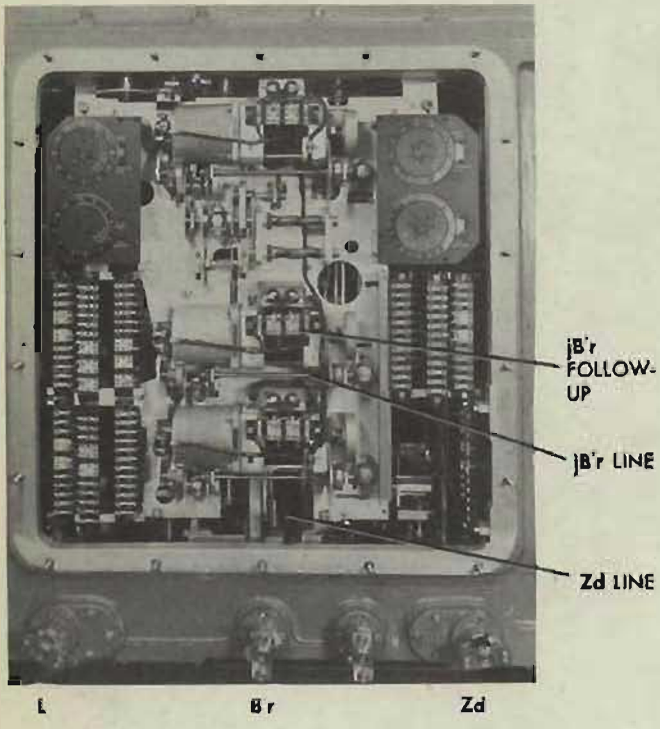






THE Vz NETWORK





CHECKING THE Br NETWORK

$Br = B'r + jB'r$

Check the $jB'r$ follow-up.

Check the $B'r$ input by checking the problem setup value on the stable element dials, and check A-602.

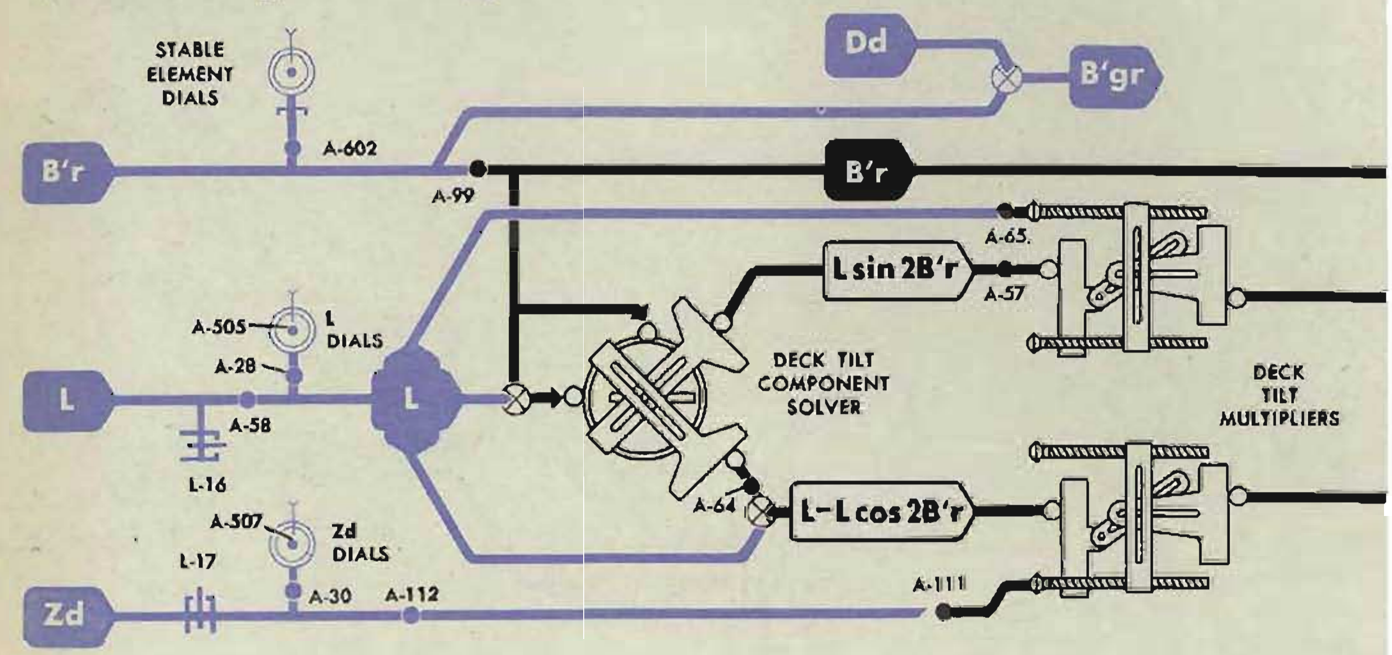
Check the L input by checking A-58 and A-28.

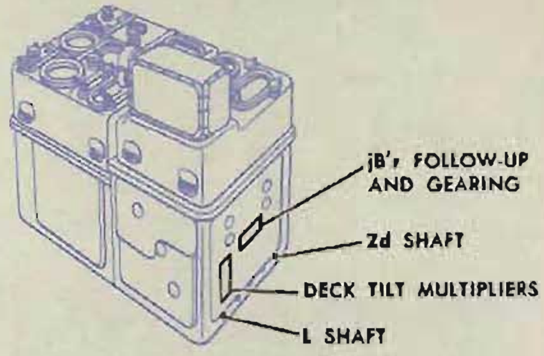
Check the Zd input by checking A-30 and A-112.

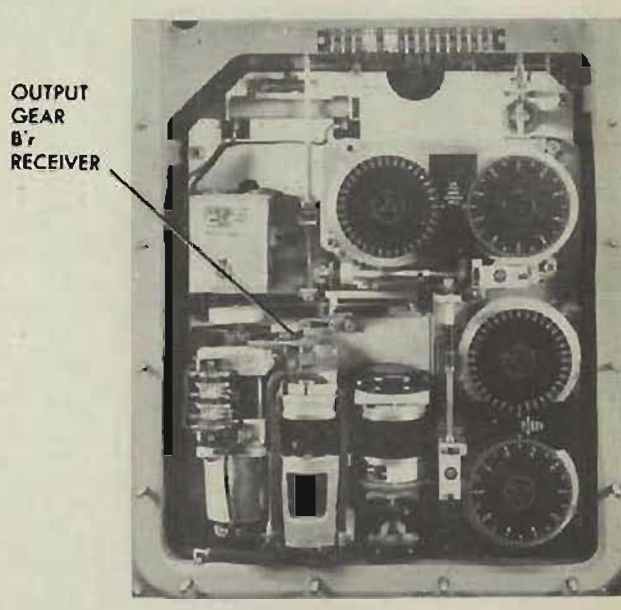
When these inputs are correct, run the unit check test of the deck tilt section, see page 220.

The unit check test will indicate errors in the inputs to the component solver or multipliers. One of the following may be incorrectly positioned:

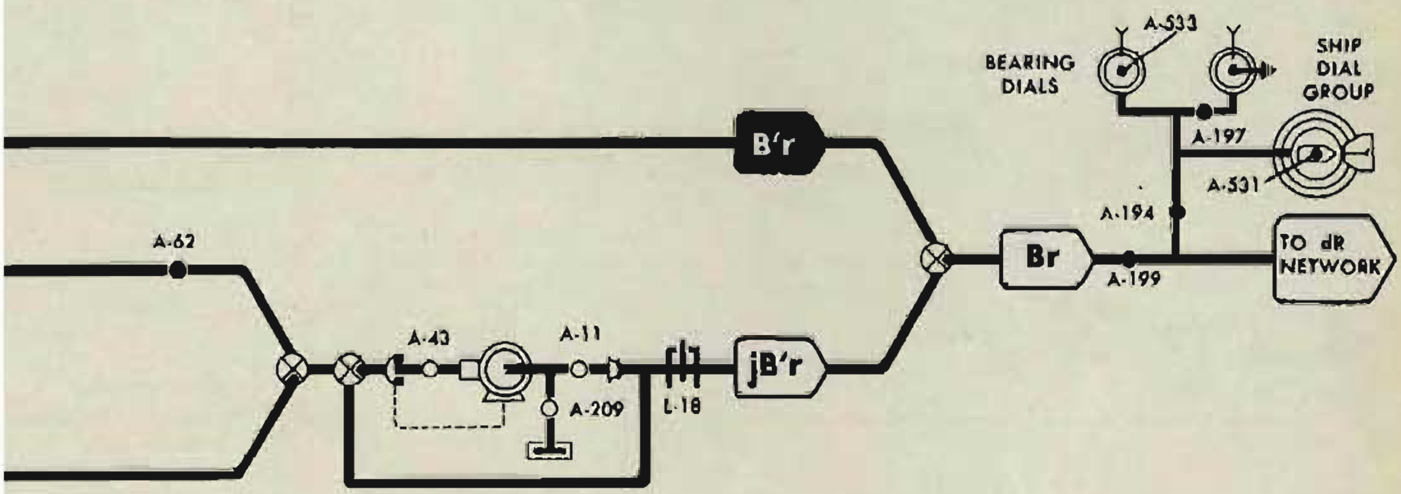
The vector gear of the deck tilt component solver. Check A-99.
The lead screw of the $L \cdot L \sin 2B'r$ multiplier. Check A-65.
The input rack of the $L \cdot L \sin 2B'r$ multiplier. Check A-57.
The lead screw of the Zd $(L - L \cos 2B'r)$ multiplier. Check A-111.
The input rack of the Zd $(L - L \cos 2B'r)$ multiplier. Check A-64.

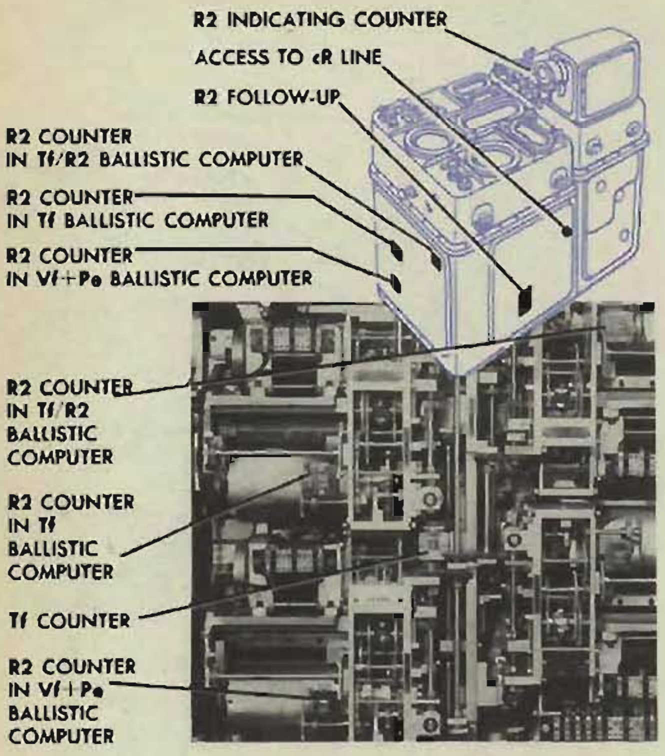






If *Br* is still in error, check A-62, A-199, A-194, A-197, and A-531.





CHECKING THE R2 NETWORK

$R2 = cR + Rtwm + Rj$

Check the *R2* follow-up.

Checking the network inputs

Check the *Tf* input.

Set the *R2* counter in the *Tf* ballistic computer at the correct intermediate value using the generated range crank in the OUT position.

Set the *E2* counter in the *Tf* ballistic computer at the correct intermediate value with the sync *E* handcrank in the CENTER position, and check the reading of the *Tf* counter against the intermediate quantity. If the value of *Tf* is still incorrect, check the *Tf* network; see page 129.

Check the *Rj* input by checking A-234 and A-235.

Check the *I.V.* input by checking A-536.

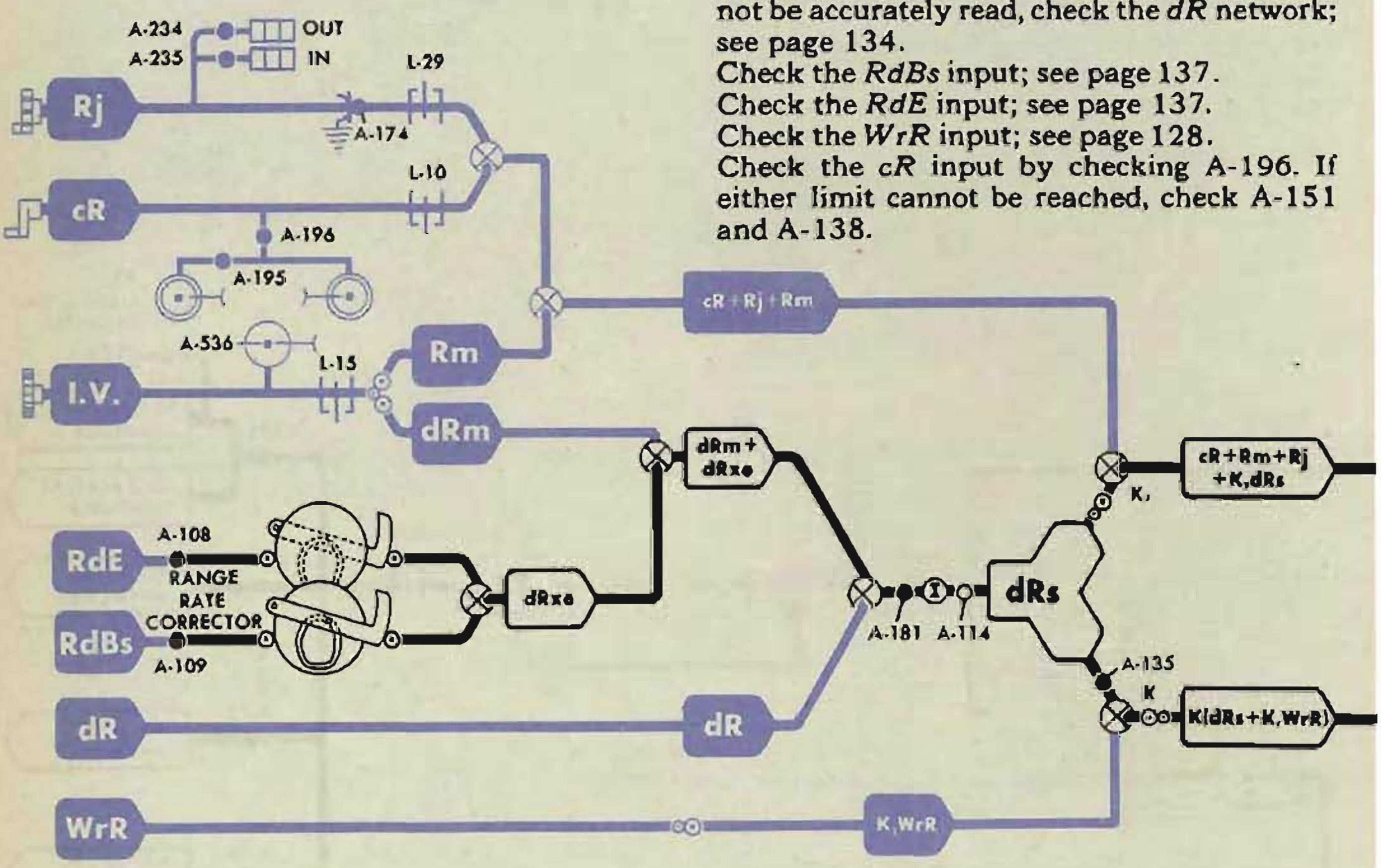
Check the *dR* input, by comparing the reading of the *dR* dial with the intermediate quantity. If the dial reading is not correct, or cannot be accurately read, check the *dR* network; see page 134.

Check the *RdBs* input; see page 137.

Check the *RdE* input; see page 137.

Check the *WrR* input; see page 128.

Check the *cR* input by checking A-196. If either limit cannot be reached, check A-151 and A-138.



Checking the mechanism inputs

When the network inputs are correct, but *R2* is still in error, check the adjustment of A-108, A-109, and A-181.

Make the range prediction multiplier check test; see page 200.

> If the lead screw is incorrectly positioned, check A-81.
> If the rack is incorrectly positioned, check A-135.
> Check A-104.

Turn the *R2* line with the generated range crank in the OUT position until the upper limit of L-19 is reached.

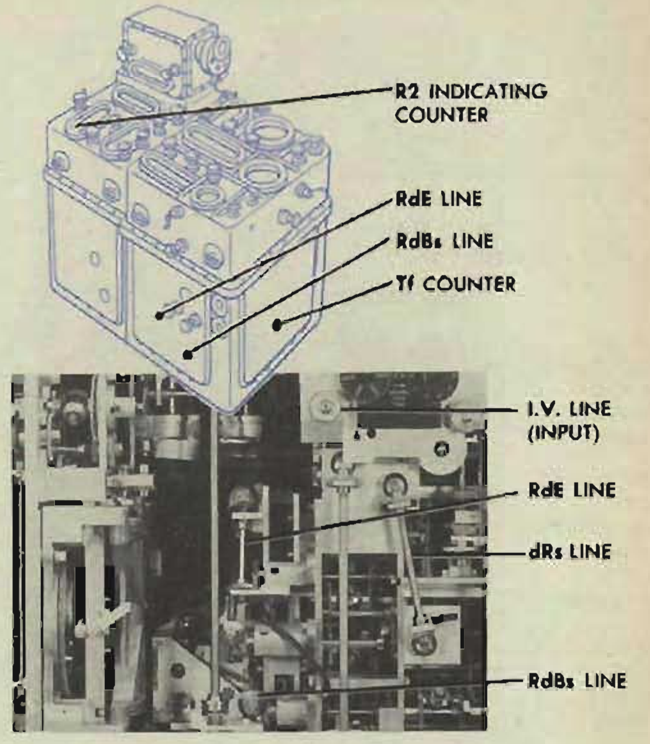
The *R2* counter in the *Tf* ballistic computer should read 18,000 yards. If this *R2* counter reading is not correct, turn the power OFF and check A-74.

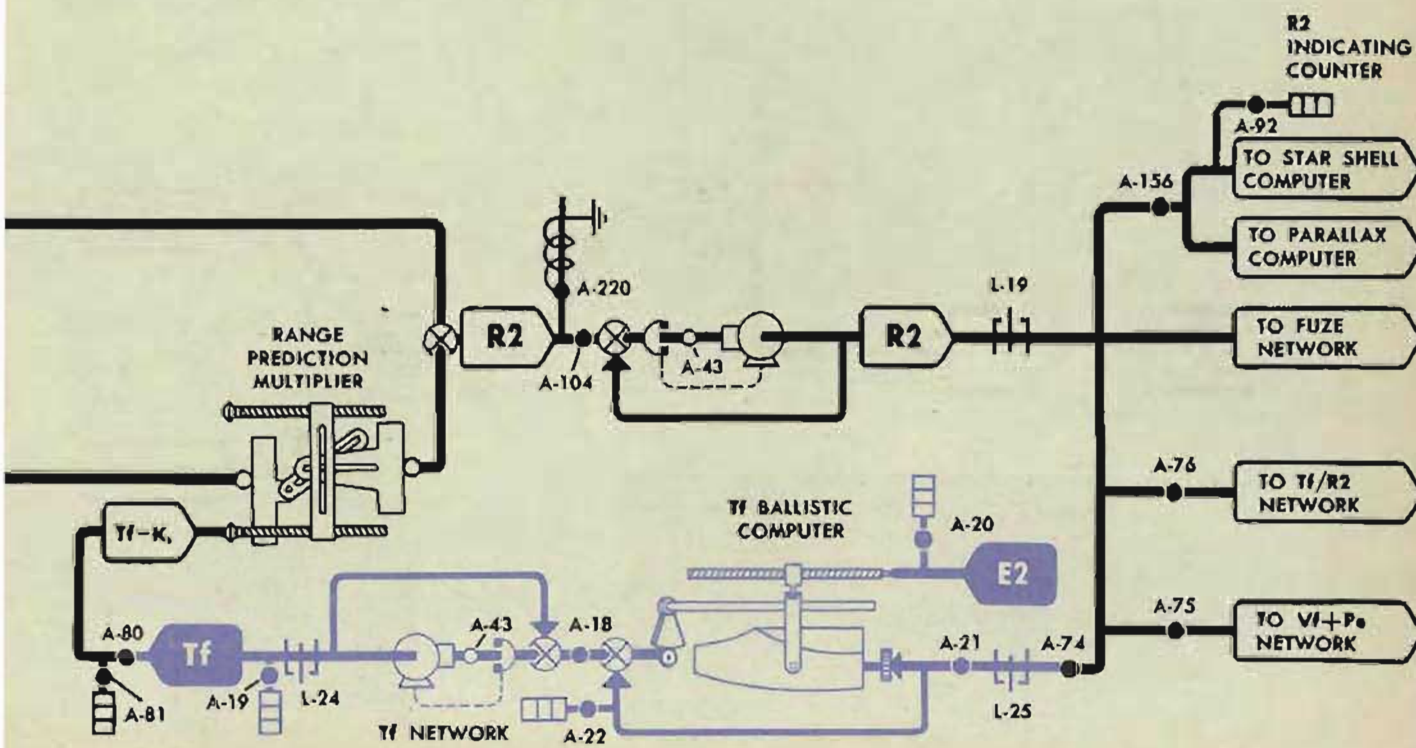
If the *R2* counter in the *Tf* ballistic computer is correct, read the *R2* counter in the *Tf/R2* ballistic computer. If it is incorrect, check A-76.

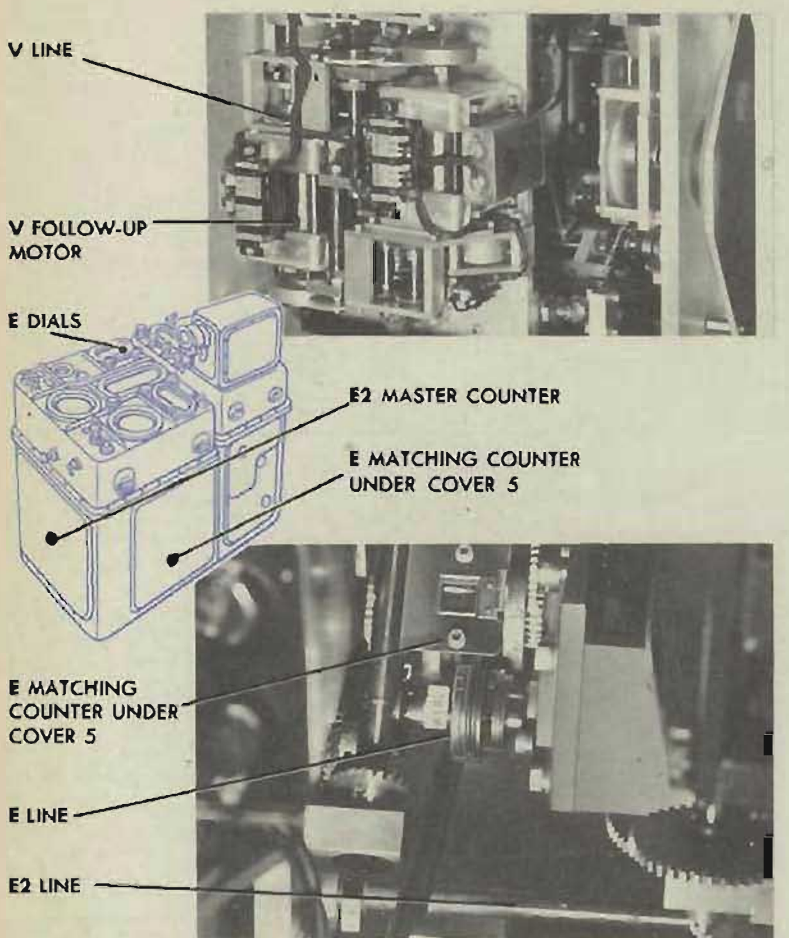
Read the *R2* counter in the *Vf + Pe* ballistic computer. If it is incorrect, check A-75.

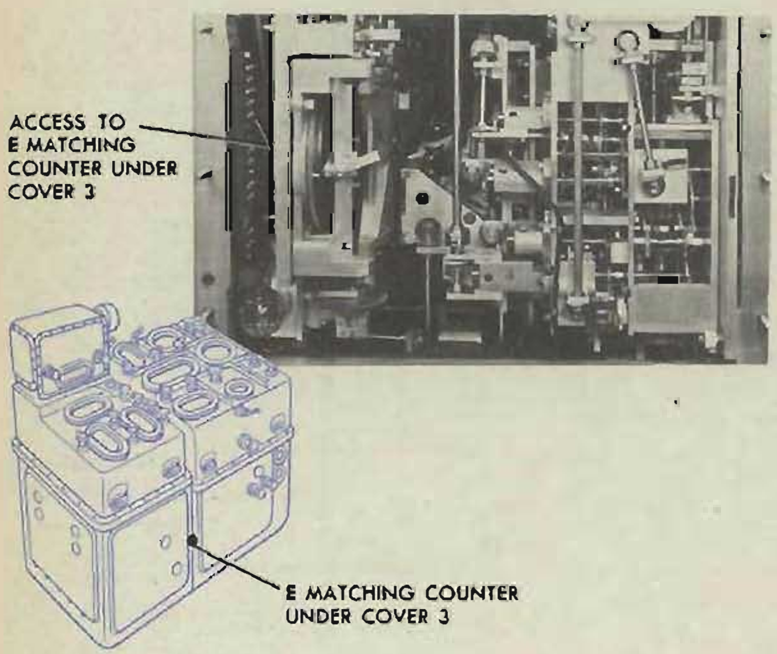
If the *R2* counters in the ballistic computers are correct and the *R2* indicating counter does not read 18,000 yards, check A-156 and A-92.

Check A-203.









CHECKING THE E2 NETWORK

$E2 = E + V$

Check the *V* follow-up.

Checking the network inputs

Check the *E* input. Increase *E* to the upper limit of L-12. The *E* dials, the *E* matching counter under cover 3, and the *E* matching counter under cover 5, should all read 85°. If all the counters read 85°, check the *V* network.

If the *E* dials do not read 85°, check A-116 and A-189.
If the *E* matching counter under cover 3 does not read 85°, check A-259.
If the *E* matching counter under cover 5 does not read 85°, check A-260. If A-260 is readjusted, check A-250.
NOTE: The *E* matching counters and A-260 are not provided on instruments with Serial Nos. 434 and lower.

Check the *V* input; see page 126.

Checking the network

When the inputs are correct, check A-103 and A-180.

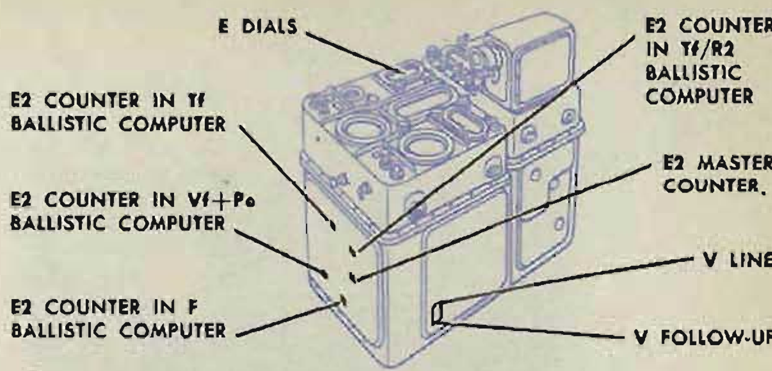
Check the *E2* intermittent drive. The *E2* intermittent drive should be at its cut-out position when the *E2* master counter reads 0° and 90°. Check that A-182 and A-114 are tight; then check A-72.

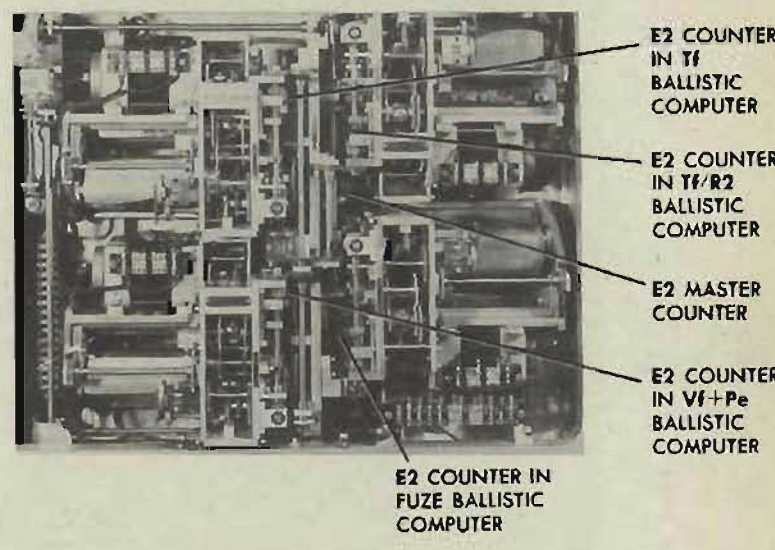
When the *E2* master counter reading is correct, check the *E2* counters by comparing the readings on all the *E2* counters with the reading on the *E2* master counter. One of the following counter readings may not agree with the master counter reading:

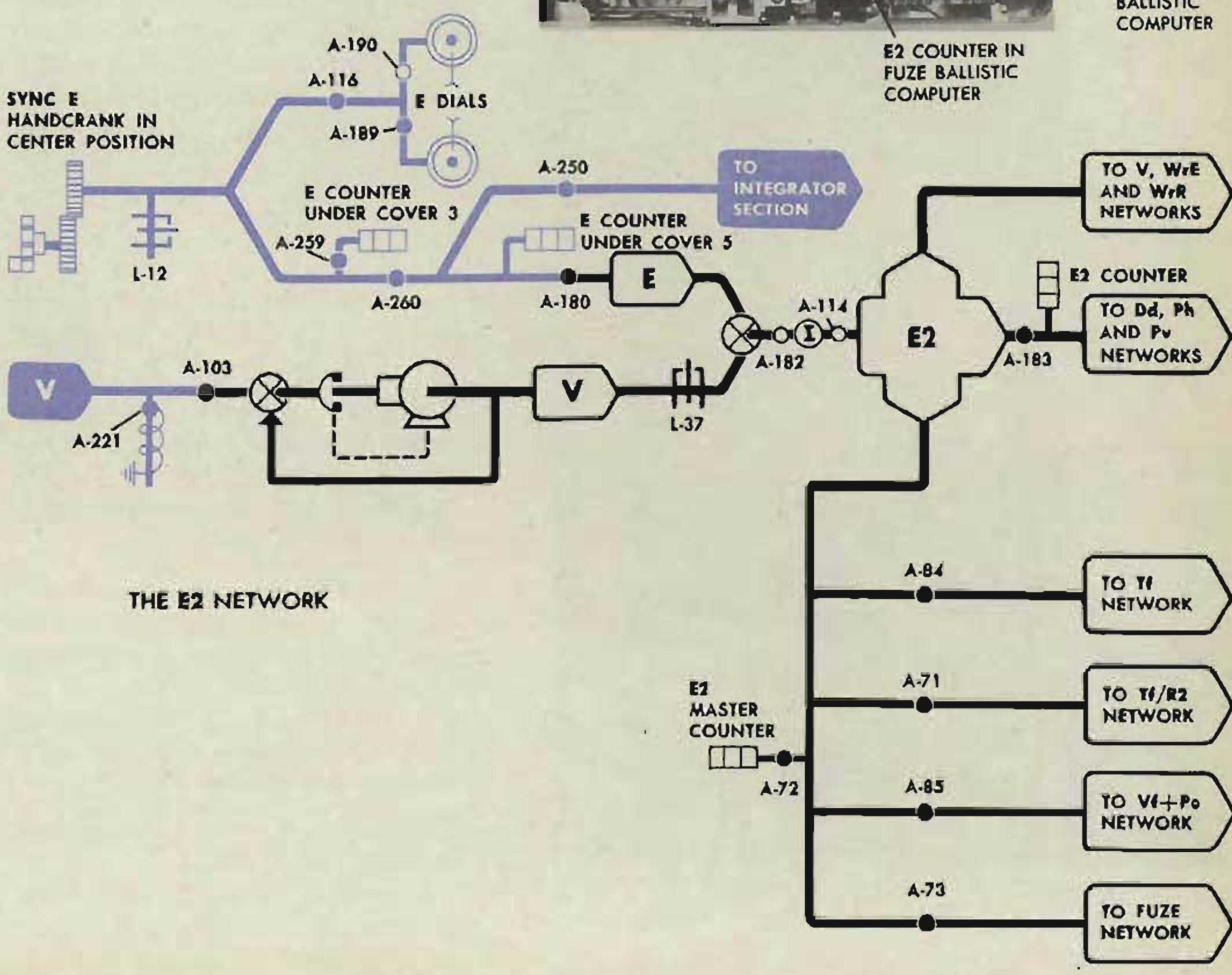
The reading on the *E2* matching counter. Check A-183.
The reading on the *E2* counter in the fuze ballistic computer. Check A-73 and A-46.

The reading on the *E2* counter in the *Tf* ballistic computer. Check A-84 and A-20.
The reading on the *E2* counter in the *Tf/R2* ballistic computer. Check A-71 and A-40.
The reading on the *E2* counter in the *Vf + Pe* ballistic computer. Check A-85 and A-15.

If an *E2* adjustment to any of the ballistic computers is altered, check the limits of the *E2* intermittent drive. If either limit cannot be reached, check whether the ballistic cam follower is butting against the limit of travel.





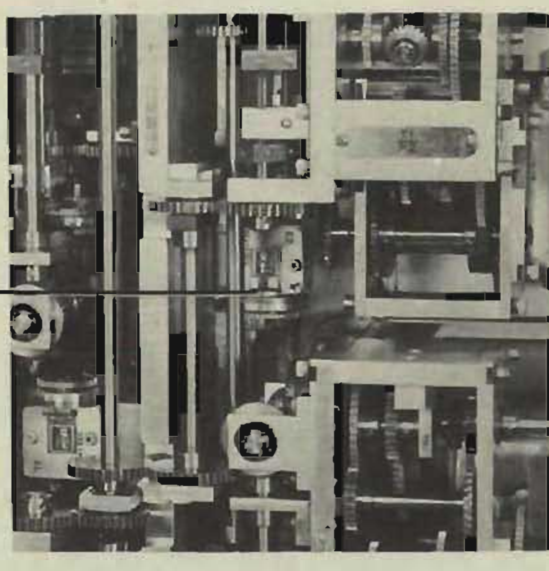


THE E2 NETWORK

CHECKING THE V NETWORK

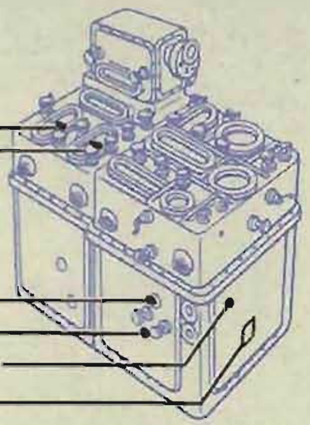
$V = Vtw' - Vx + (KVj + K_3RdE)$

Check the V follow-up.



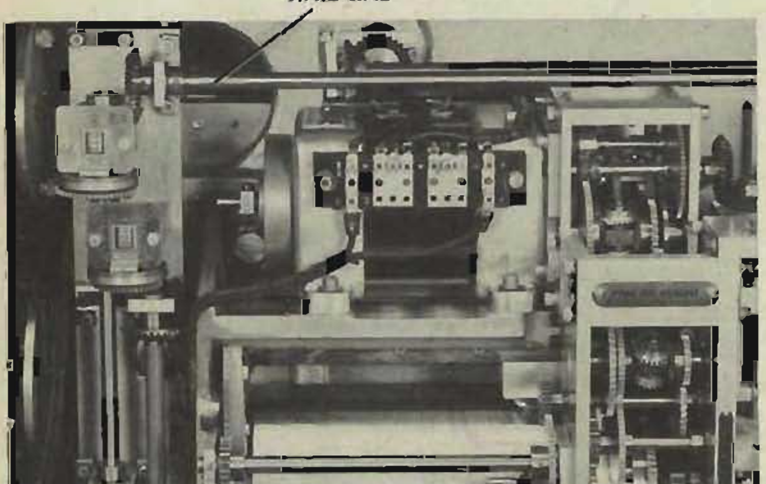
Checking the network inputs

Check the $E2$ input by comparing the reading on the $E2$ master counter with the value given in the intermediate quantities. If the counter reading does not agree with the value given, check the $E2$ network; see page 124.



Check the Ds input by comparing the reading on the Ds indicating counter with the value given on the problem results form. If the counter reading does not agree with the value given, check the Ds network; see page 110.

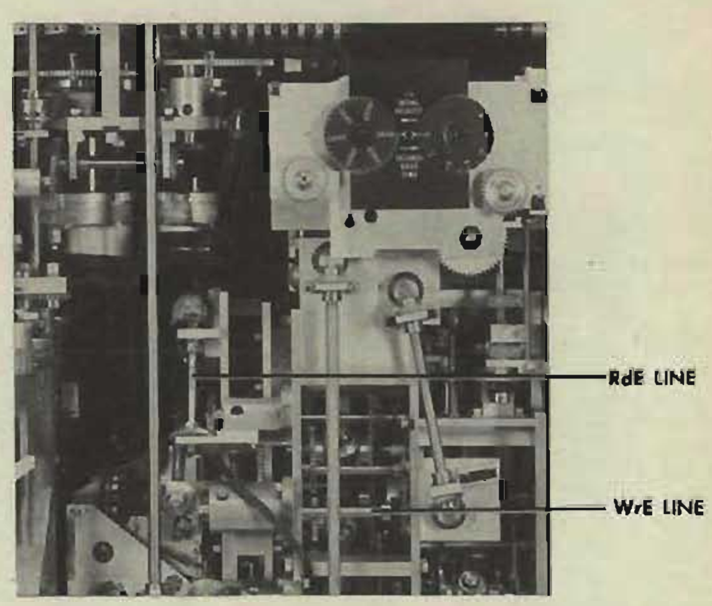
Check the $Tf/R2$ input by comparing the reading on the $Tf/R2$ counter with the value given in the intermediate quantities. If the counter reading does not agree with the value given, check the $Tf/R2$ network; see page 130.



Check the Vj input by checking A-501.

Check the *RdE* input; see page 137.

Check the *WrE* input; see page 128.



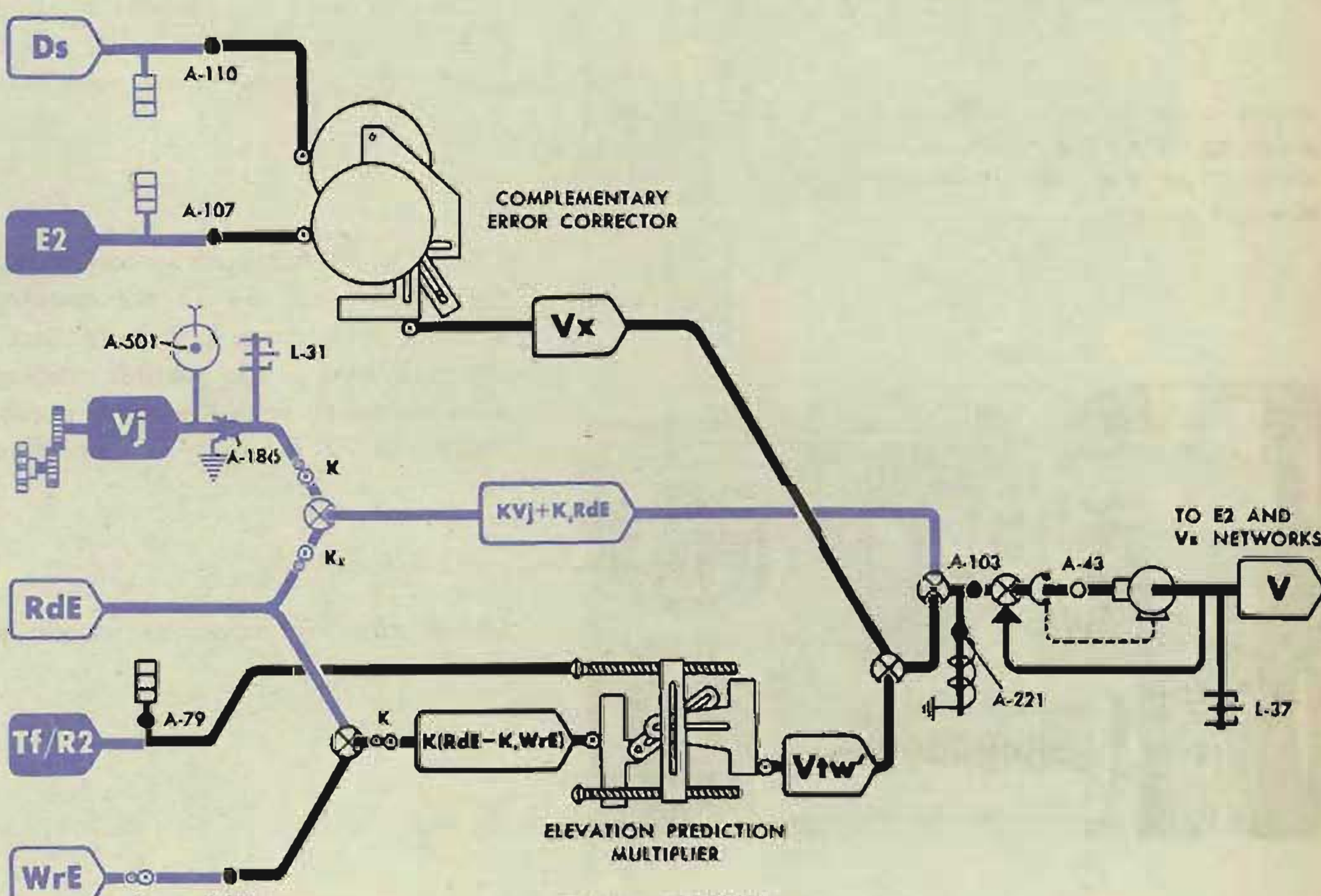
Checking the network

When the inputs are correct, check A-107 and A-110.

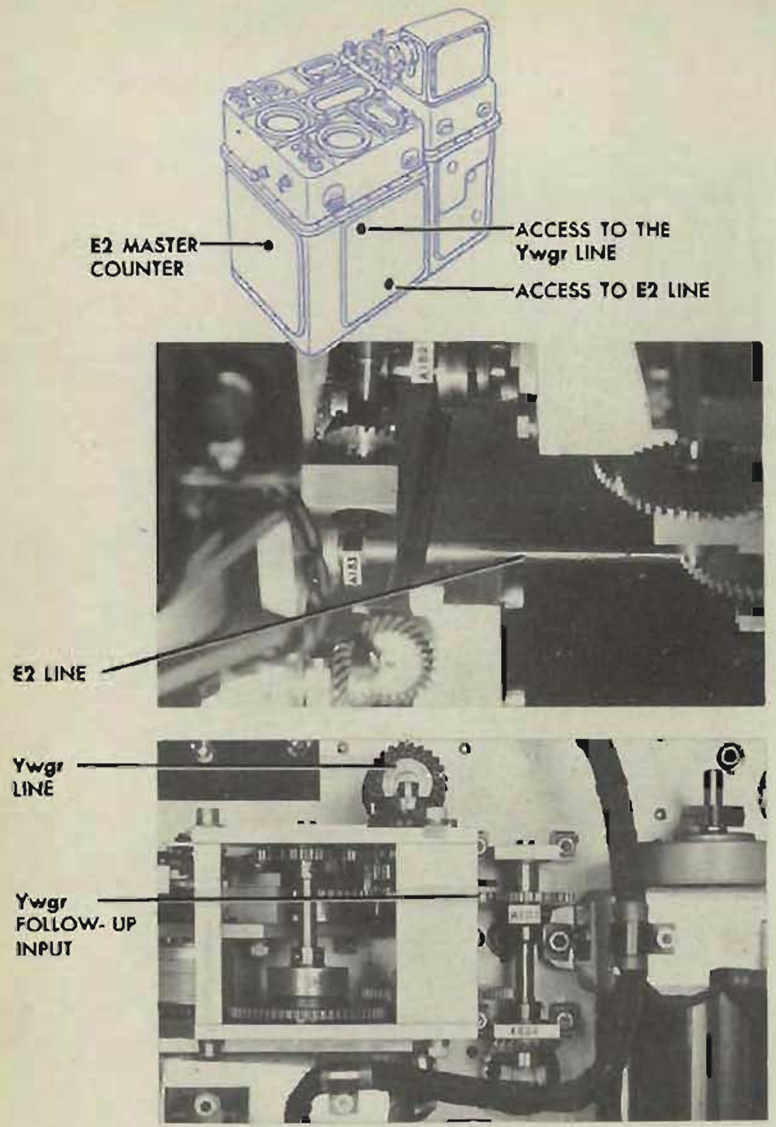
Make the elevation prediction multiplier check test; see page 202.

> If the lead screw is incorrectly positioned, check A-79.
> If the rack is incorrectly positioned, check A-134.

If *V* is still in error, check A-221 and A-103.



THE V NETWORK



CHECKING THE WrR AND WrE NETWORKS

$WrR = Ywgr \cos (KE2)$
$WrE = Ywgr \sin (KE2)$

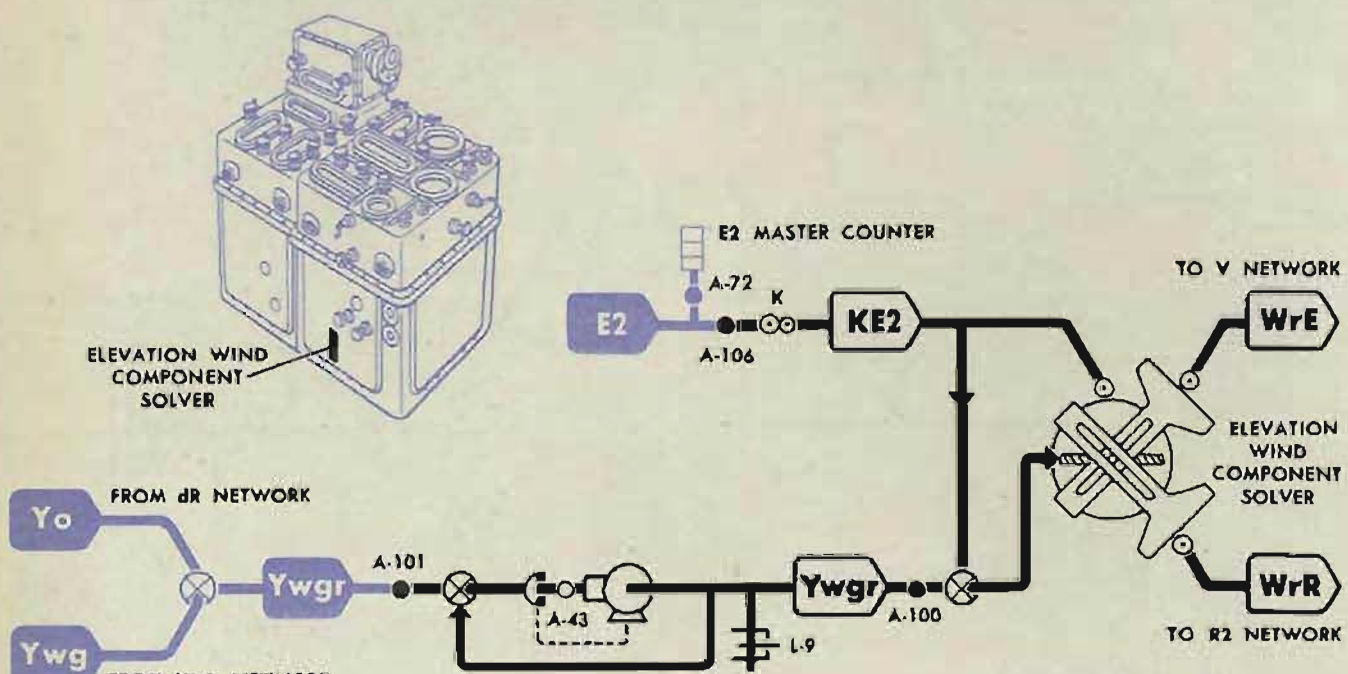
Check the *Ywgr* follow-up.

Check the *E2* input by comparing the reading on the *E2* master counter with the *E2* intermediate quantity. If the counter reading agrees with the value given, *E2* is correct. If the counter reading does not agree with the value given, check the *E2* network; see page 124.

Check the *Ywgr* input by checking the *WrD* network; see page 138. If *WrD* is correct, *Ywg* and *Yo* are also correct.

When the network inputs are correct, run the unit check test of the elevation wind component solver; see page 196.

If the speed pin is incorrectly positioned, check A-101 and A-100. If the vector gear is incorrectly positioned, check A-106.



THE WrE AND WrR NETWORKS

CHECKING THE Tf NETWORK

Check the *Tf* follow-up.

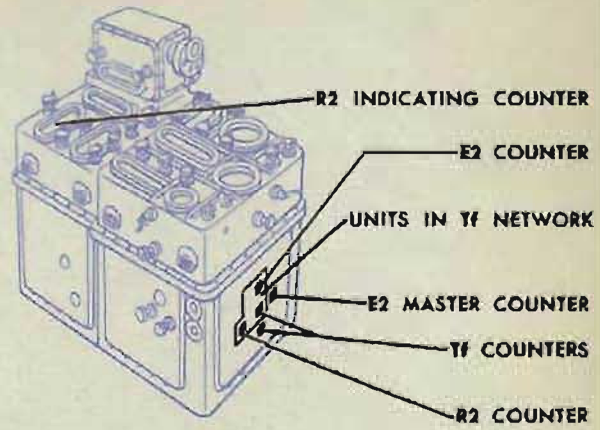
Check the *E2* input by comparing the reading on the *E2* master counter with the *E2* intermediate quantity. If the reading does not agree with the value given, check the *E2* network; see page 124.

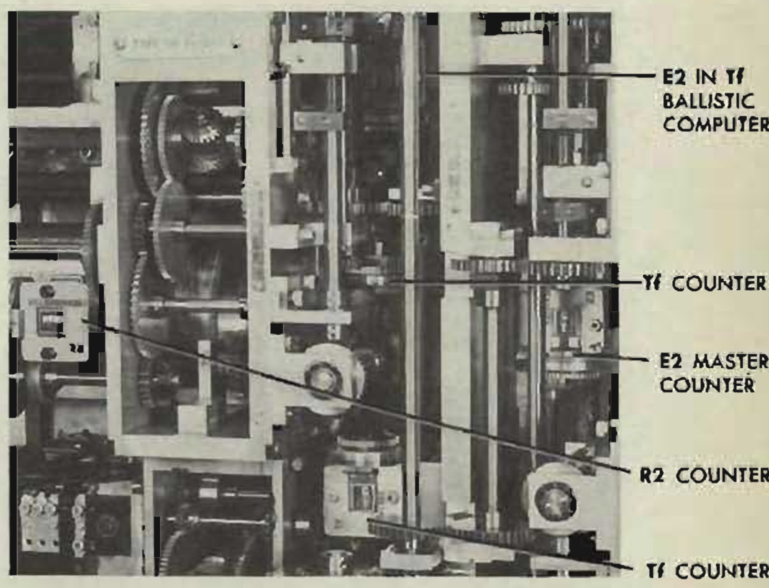
Check the *R2* input by comparing the reading on the *R2* counter in the *Tf* ballistic computer with the *R2* intermediate quantity. If the reading does not agree with the value given, check the *R2* network; see page 122.

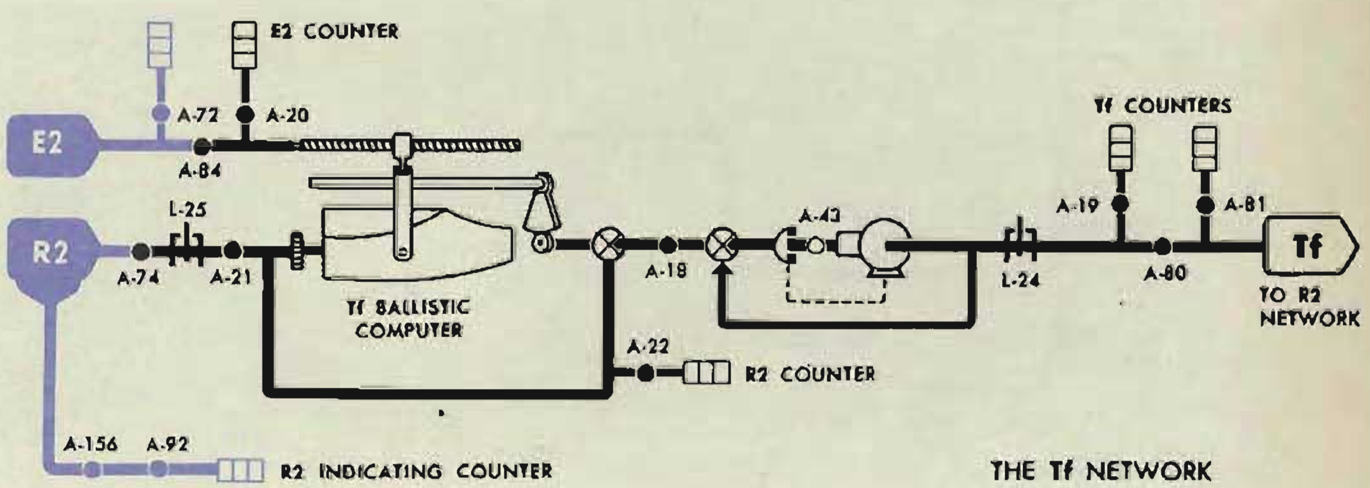
When the network inputs are correct, compare the reading on the *E2* ballistic counter with the reading on the *E2* master counter. If the ballistic counter reading is in error, check A-84.

When the *E2* and *R2* ballistic counter readings are correct but *Tf* is in error, make the *Tf* ballistic computer unit check test, see page 208.

If any adjustments are made, recheck A-84; then check A-74 and A-80.







THE Tf NETWORK

CHECKING THE Tf/R2 NETWORK

Check the *Tf/R2* follow-up.

Check the *E2* input by comparing the reading on the *E2* master counter with the *E2* intermediate quantity. If the reading does not agree with the value given, check the *E2* network. See page 124.

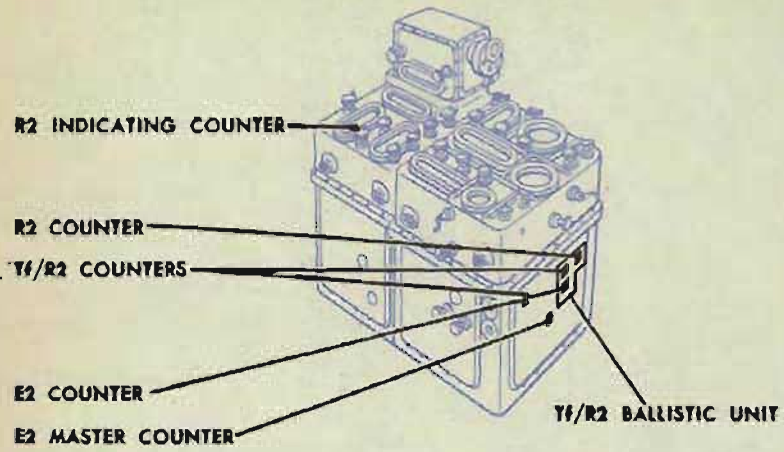
Check the *R2* input by comparing the reading on the *R2* counter in the *Tf* ballistic computer with the *R2* intermediate quantity. If the reading does not agree with the value given, check the *R2* network. See page 122.

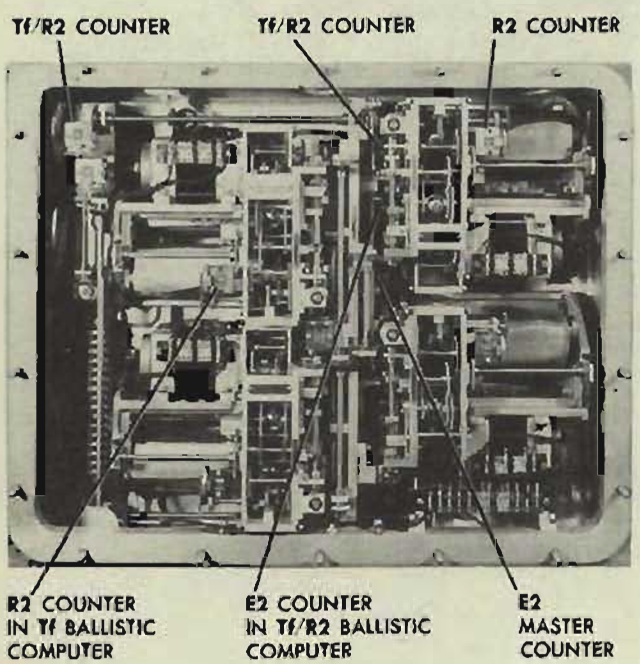
When the network inputs are correct, compare the reading on the *E2* ballistic counter with the reading on the *E2* master counter. If the ballistic counter reading is in error, check A-71.

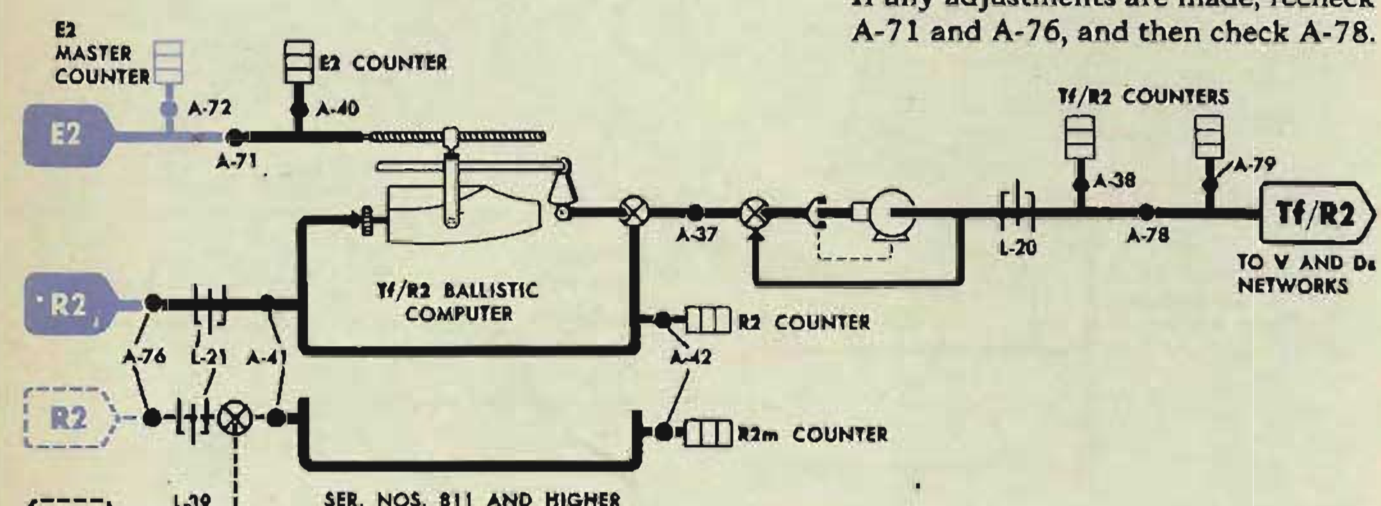
Compare the reading on the *R2* (or *R2m*) ballistic counter with the reading on the *R2* counter in the *Tf* ballistic computer (on Serial Nos. 811 and higher, set front *I.V.* dial at 2550 f.s.). If the readings do not agree, check A-76 (also A-607 on Serial Nos. 811 and higher).

When the *E2* and *R2* ballistic counter readings are correct but *Tf/R2* is in error, make the *Tf/R2* ballistic computer unit check test; see page 208.

If any adjustments are made, recheck A-71 and A-76, and then check A-78.







THE Tf/R2 NETWORK

CHECKING THE Vf + Pe NETWORK

Check the *Vf* + *Pe* follow-up.

Check the *E2* input by comparing the reading on the *E2* master counter with the *E2* intermediate quantity. If the reading does not agree with the value given, check the *E2* network. See page 124.

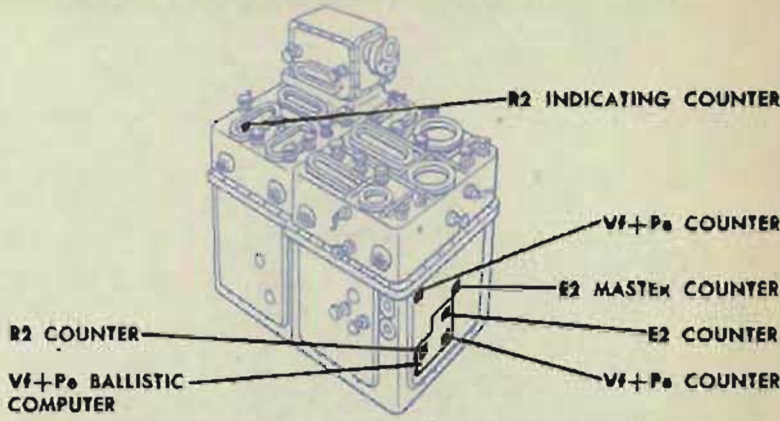
Check the *R2* input by comparing the reading on the *R2* counter in the *Tf* ballistic computer with the *R2* intermediate quantity. If the reading does not agree with the value given, check the *R2* network; see page 122.

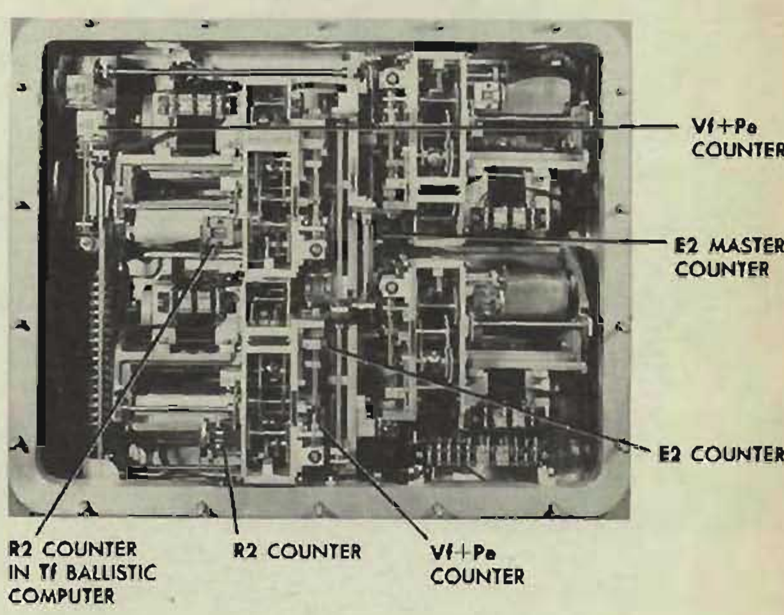
When the network inputs are correct, compare the reading on the *E2* ballistic counter with the reading on the *E2* master counter. If the readings do not agree, check A-85.

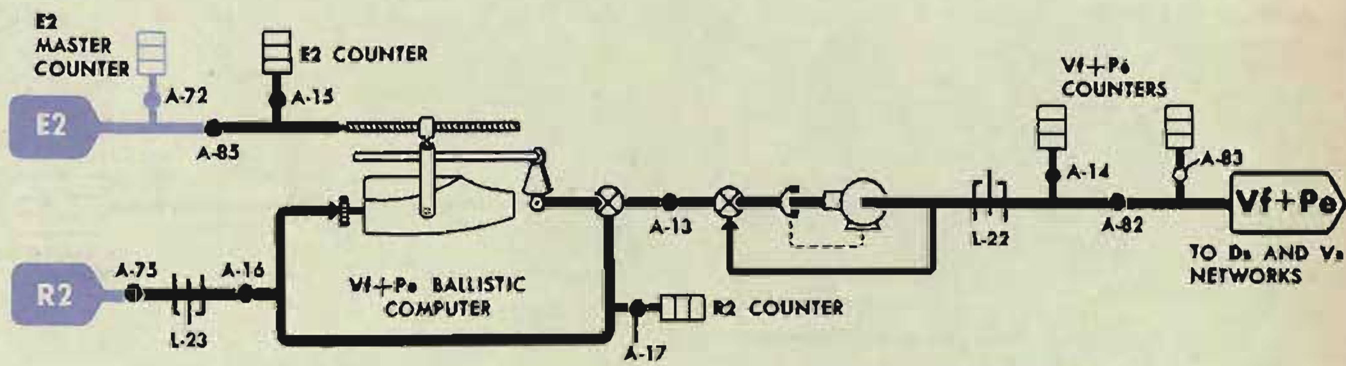
Compare the reading on the *R2* ballistic counter with the reading on the *R2* counter in the *Tf* ballistic computer. If the readings do not agree, check A-75.

When the *E2* and *R2* ballistic counter readings are correct but *Vf* + *Pe* is in error, make the *Vf* + *Pe* ballistic computer unit check test; see page 208.

If any adjustments are made, recheck A-85 and A-75. Then check A-82.



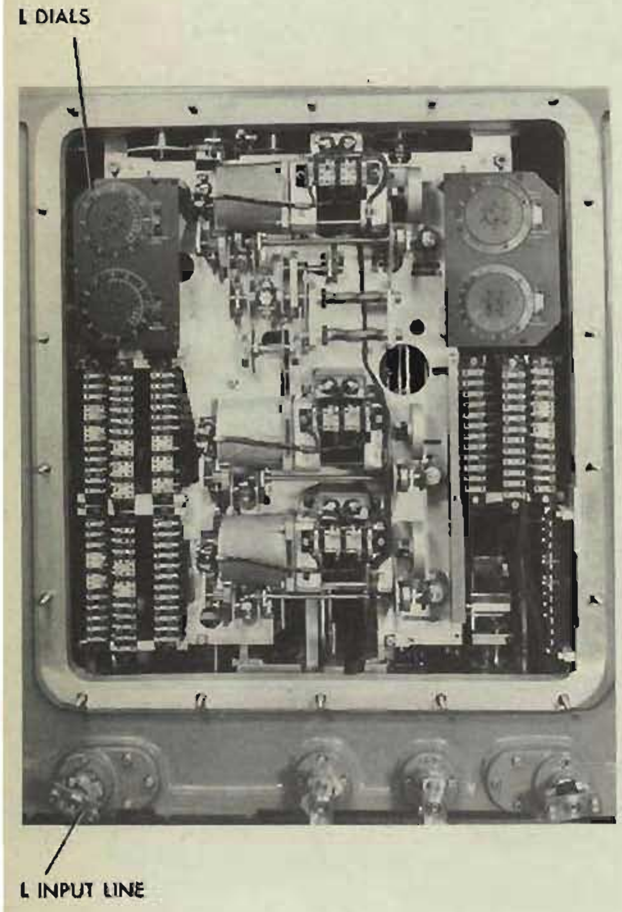




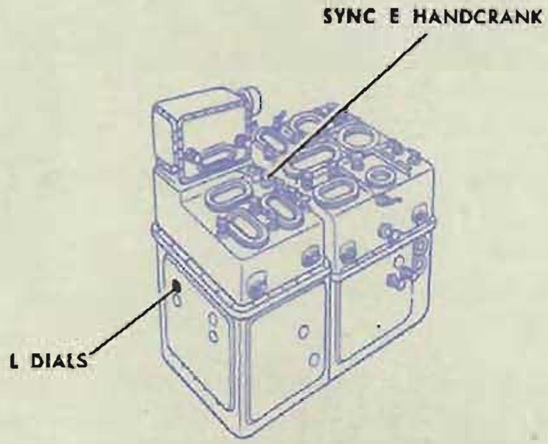
THE Vf+Pe NETWORK

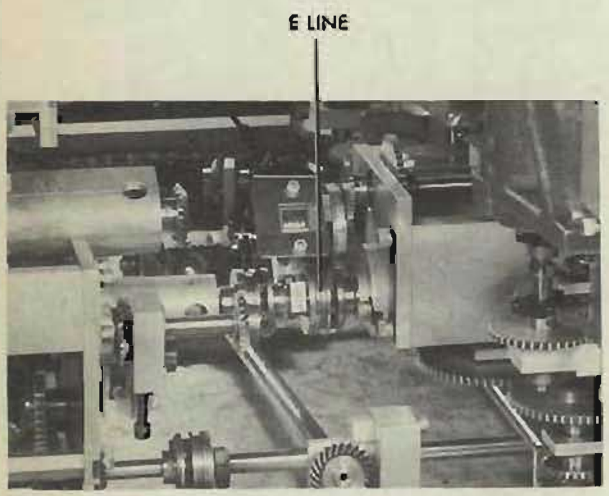
CHECKING THE SYNCHRONIZE ELEVATION NETWORK

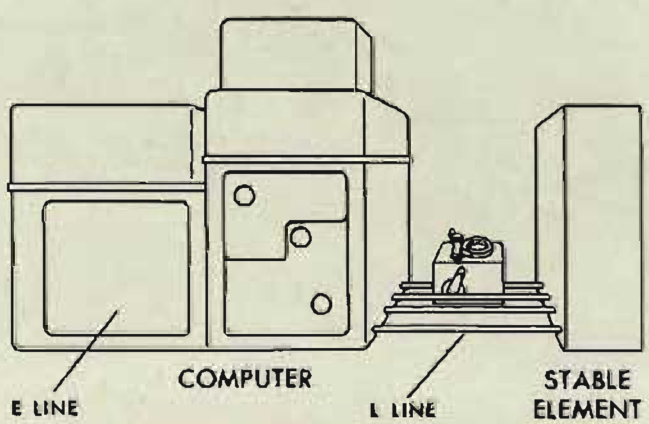
During A tests, $Eb = E + L$.



Check the L input by comparing the reading on the computer L dials with the reading on the stable element L dials. Run the L line to both limits. The stable element limit stop should stop the line at 3500′ and 500′. If the readings do not agree, or the limits cannot be reached, check A-58, A-601, A-28, and A-505.

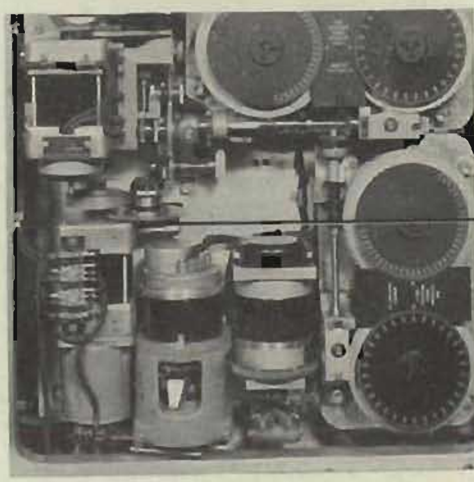




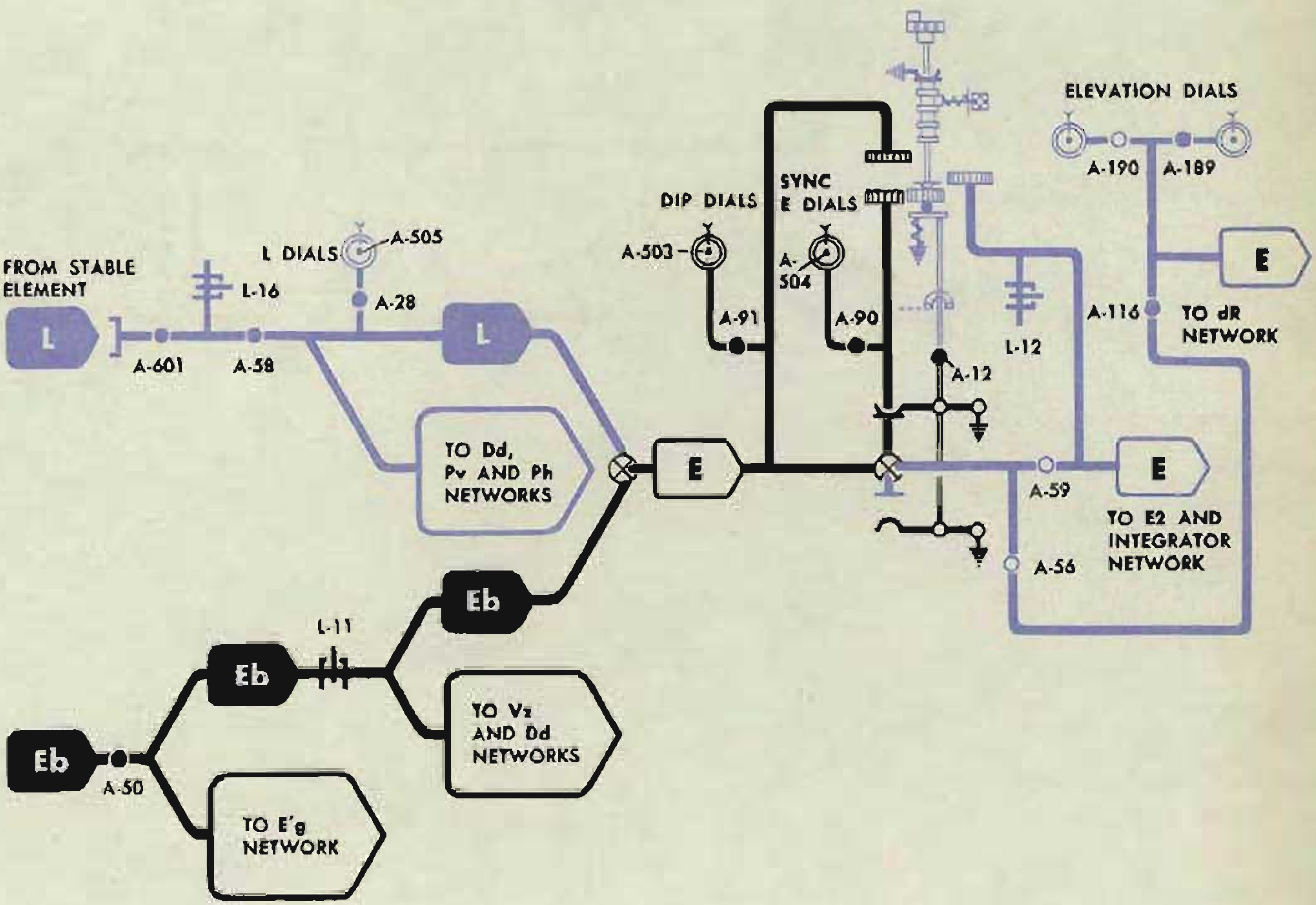


Check the E input by turning the E line to both limits with the synchronize elevation handcrank in the CENTER position. At the limits of L-12, the E dials should read $-25°$ (or $-5°$ for Serial Nos. 389 and lower) and $+85°$. If the E dials do not read $-25°$ and $+85°$, check A-116 and A-189.

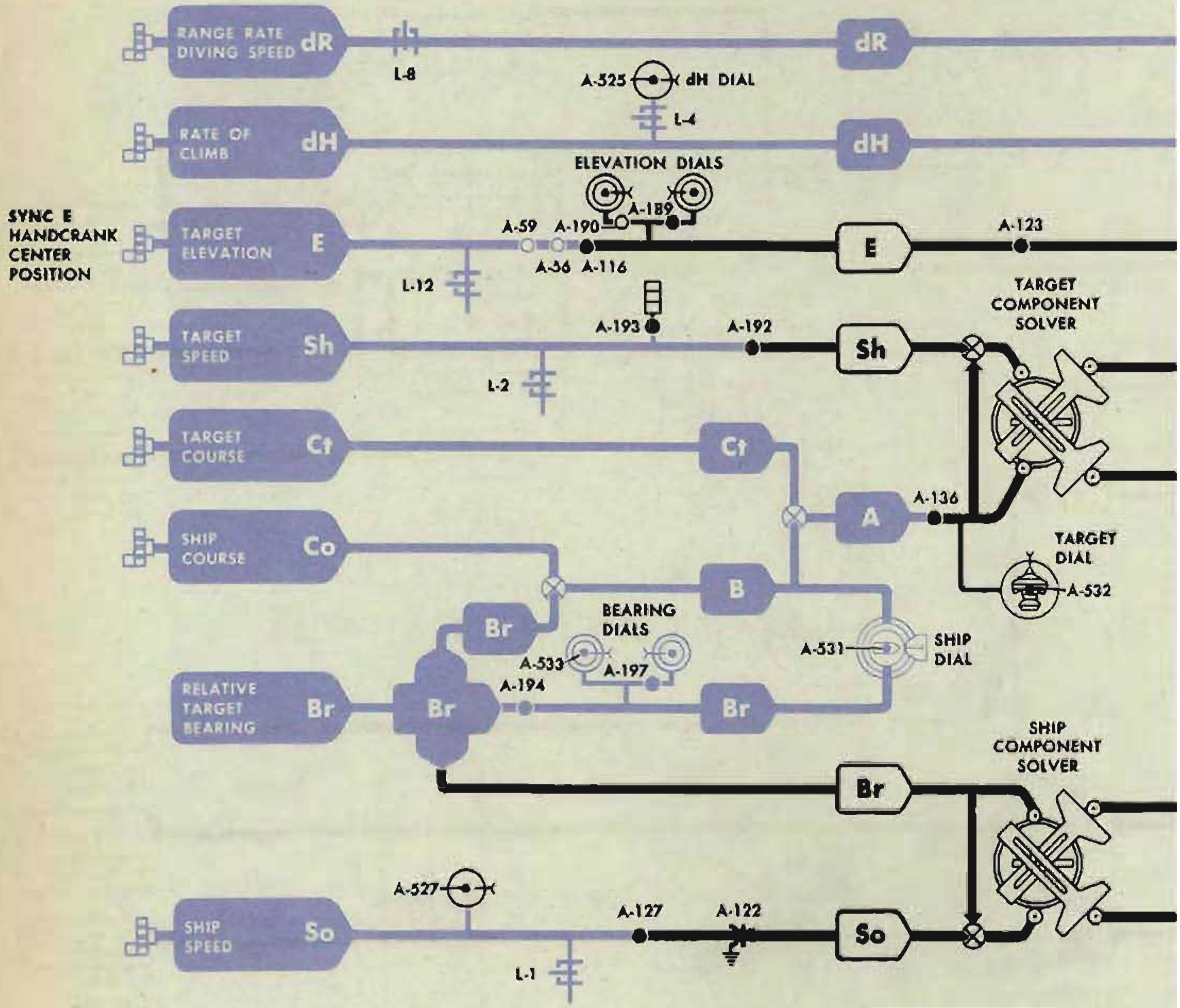
When the network inputs (E and L) are correct, check A-12, A-90, A-504, A-91, and A-503.

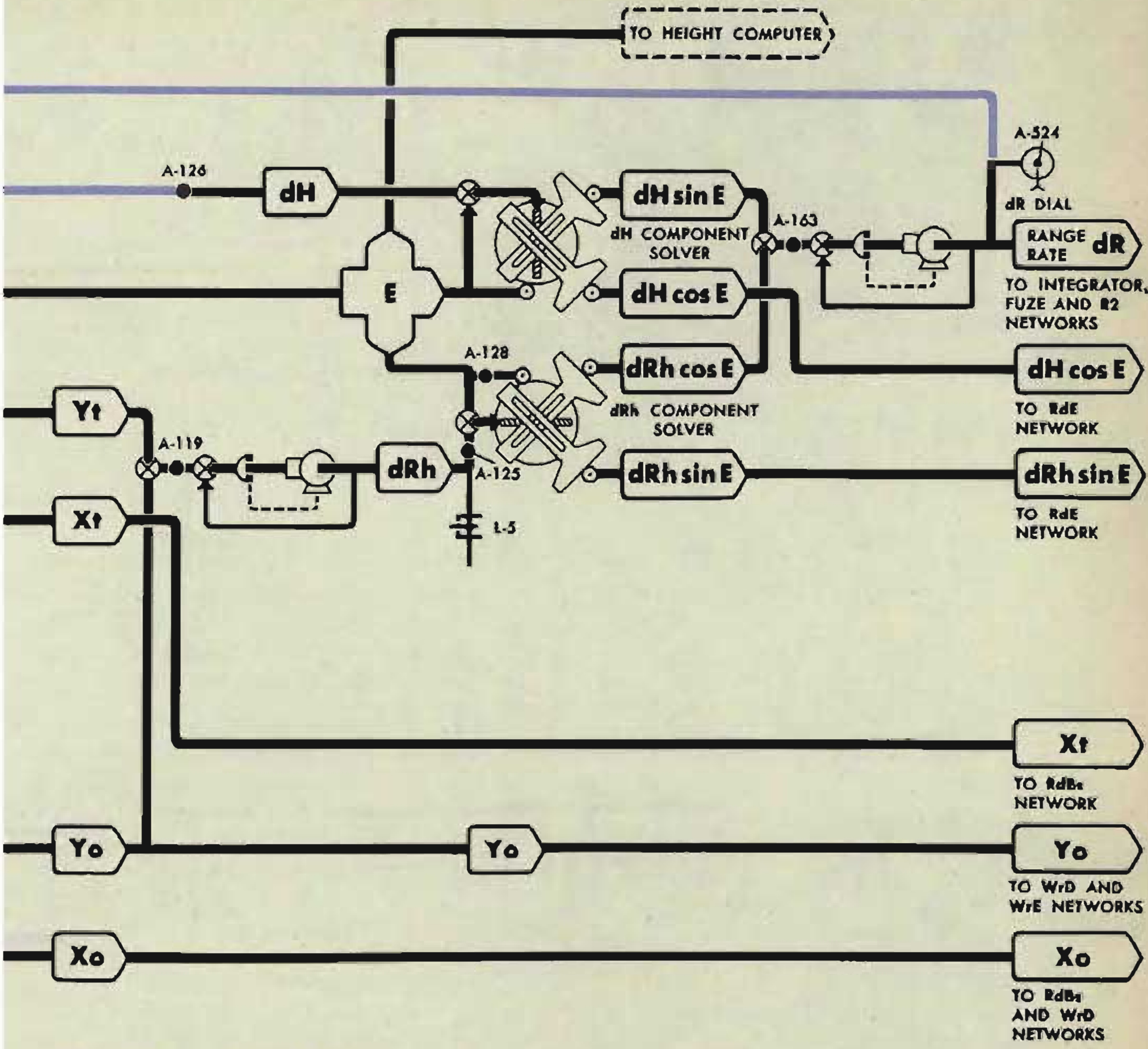


SYNCHRONIZE ELEVATION NETWORK



CHECKING THE dR NETWORK

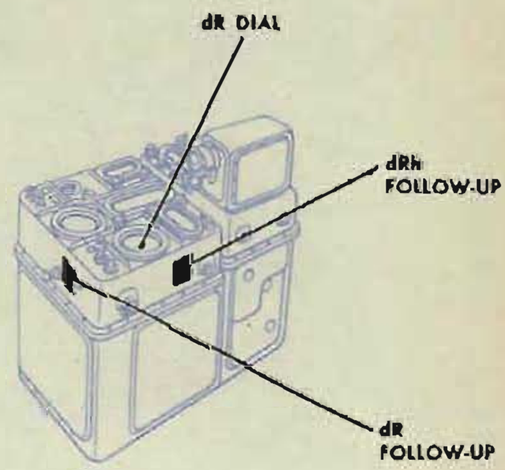


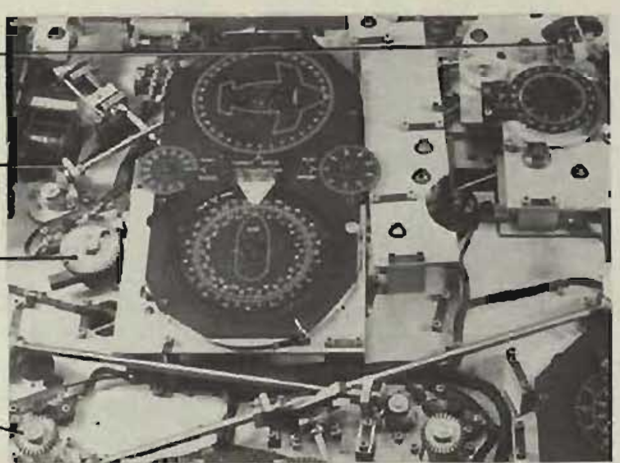


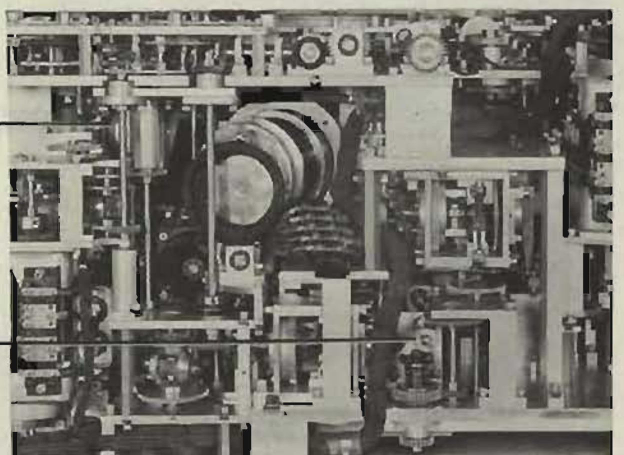
Checking the follow-ups

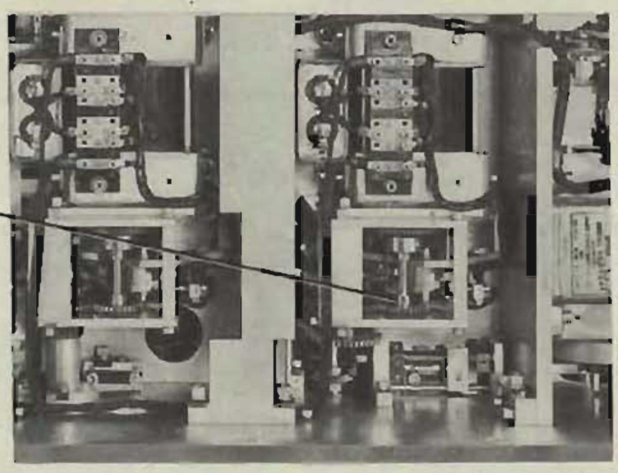
$dR = dH \sin E + dRh \cos E$

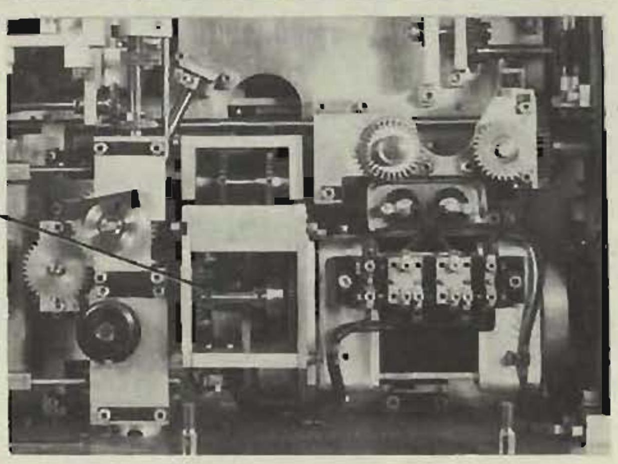
Check the *dR* dial against the values given in the intermediate quantities. Positive values of *dR* cannot be read because the dial is graduated only on the negative side. Since the dial is graduated at ten-knot intervals, small errors cannot be seen. To obtain the most accurate check, a test problem should be set up in which *dR* has a value very close to a graduation on the dial. Such problems are 5, 9, and 13. If the *dR* dial reading does not agree with the specified value, check the *dRh* follow-up, the *dR* dial and follow-up, A-119, A-524, and A-163.

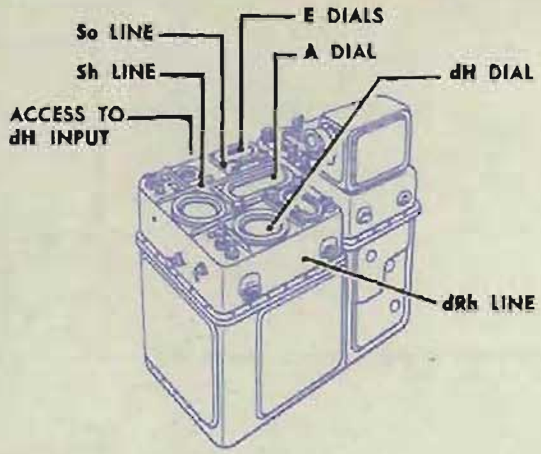












Checking the component solvers

Run the unit check test of the relative motion group; see page 190. The unit check test may indicate an error in one of the component solvers. Remove cover 1. Any of the following may be incorrectly positioned:

1 The speed pin of the ship component solver; check the *So* input line by checking A-527 and A-127.
2 The speed pin of the target component solver; check the *Sh* input line by checking A-193 and A-192.
3 The vector gear of the ship component solver; check A-194.
4 The vector gear of the target component solver; check the *A* line by checking A-532.
5 The speed pin of the *dH* component solver; check the *dH* input line by checking A-525 and A-126.
6 The speed pin of the *dRh* component solver; check the *dRh* line by checking A-119 and A-125.
7 The vector gear of the *dH* component solver; check the *E* line by checking A-116, A-189 and A-123.
8 The vector gear of the *dRh* component solver; check the *E* line by checking A-128. (A-123 should always be checked and adjusted before A-128.)

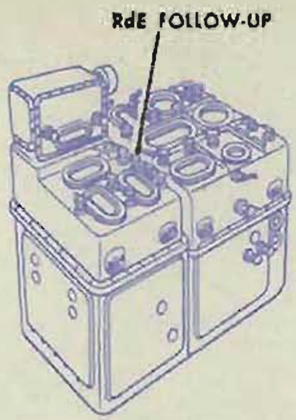
CHECKING THE RdE NETWORK

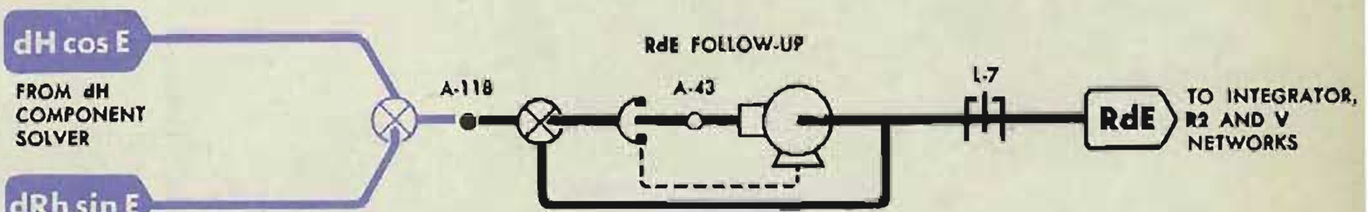
$RdE = dH \cos E - dRh \sin E$

Check the dR network; see page 134. If dR is correct, $dH \cos E$ and $dRh \sin E$ may be assumed to be correct.

Check the RdE follow-up.

Check A-118.





RdE NETWORK

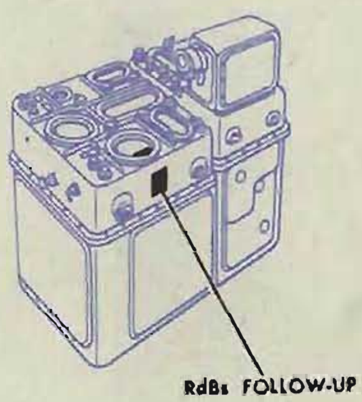
CHECKING THE RdBs NETWORK

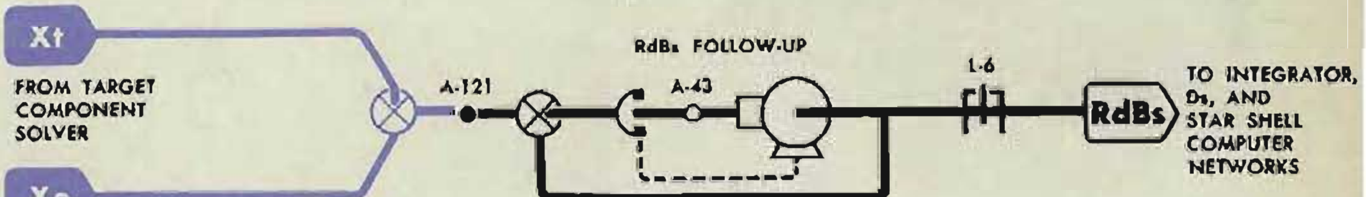
$RdBs = Xo + Xt$

Check the dR network; see page 134. If dR is correct, Xo and Xt may be assumed to be correct.

Check the $RdBs$ follow-up.

Check A-121.

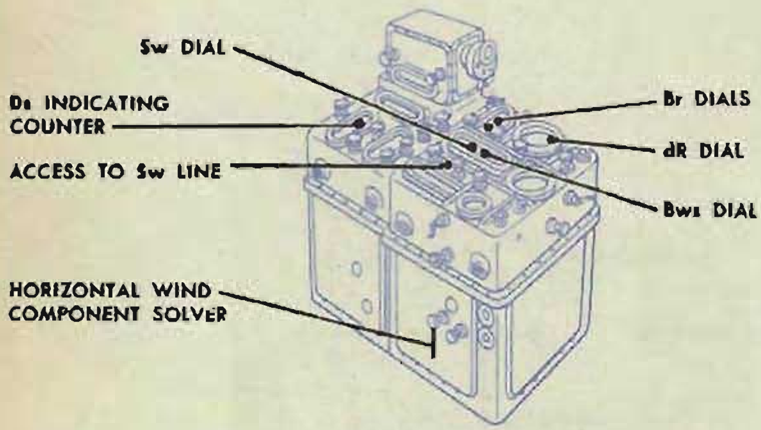




RdBs NETWORK

CHECKING THE WrD NETWORK

$WrD = Xo + Xwg$



Checking the network inputs

Check the *Xo* input by checking the *dR* network. See page 134.

Check the *Ds* input by comparing the reading on the *Ds* indicating counter with the value given on the problem results form. If the counter reading agrees with the value given, the *Ds* input is correct.

If the *Ds* counter reading does not agree with the value given, check the *Ds* network; see page 110.

Check the *Sw* input by checking A-528.

Check the *Br* input by comparing the reading on the *Br* dial with the *Br* quantity. If the dial reading agrees with the value given, the *Br* input is correct.

If the *Br* dial reading does not agree with the value given, check the *Br* network; see page 120.

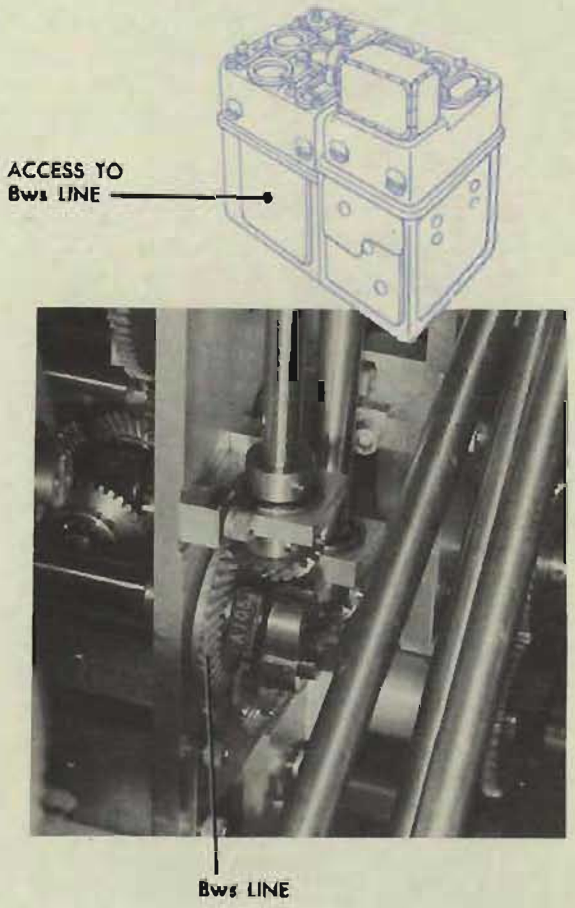
Co and *Bw* are input settings and therefore can be assumed to be correct.

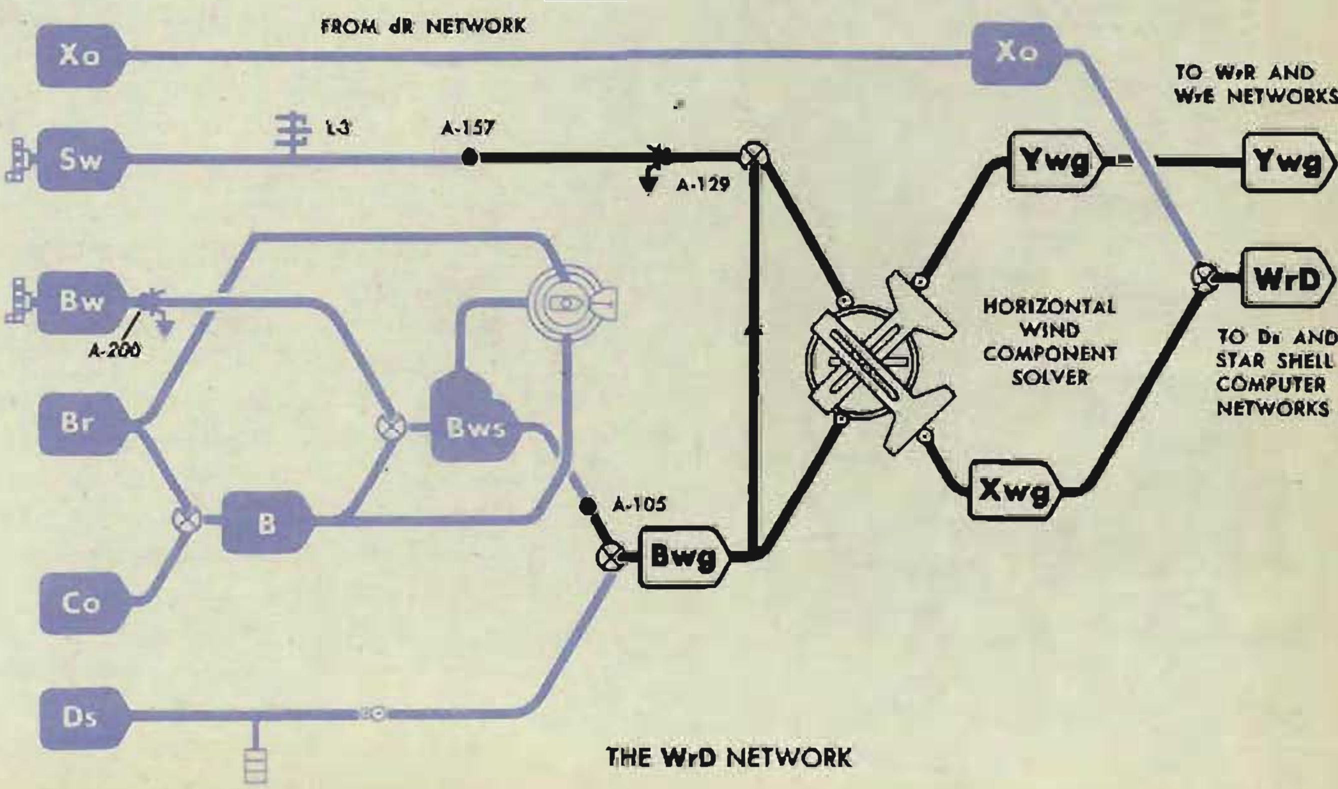
Checking the network

When the network inputs are correct, run the unit check test of the horizontal wind component solver; see page 194.

If the speed pin is incorrectly positioned, check A-157.

If the vector gear is incorrectly positioned, check A-105.





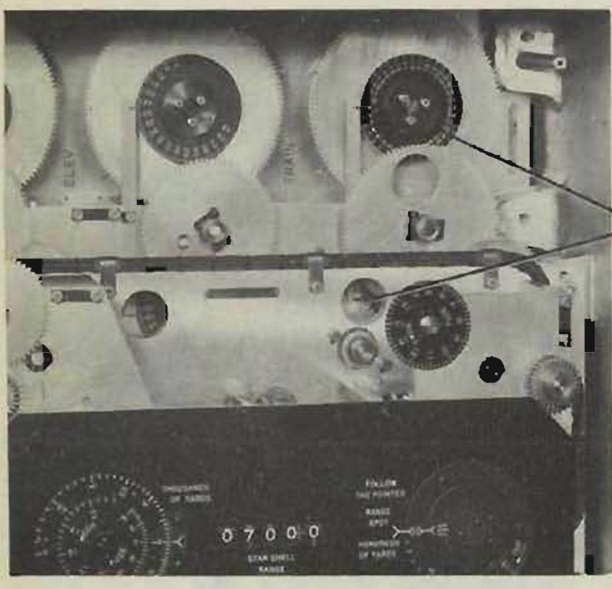
THE WrD NETWORK

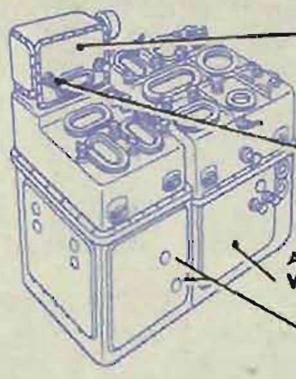
ERRORS IN B'grn

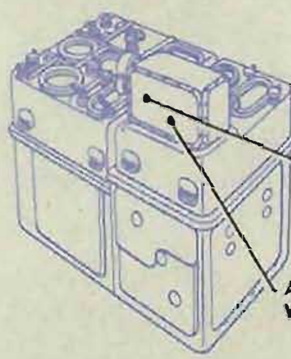
Checking the network inputs

Check the *R2* input by comparing the reading on the computer *R2* counter with the value given in the intermediate quantities. If the counter reading does not agree with the value given, check the *R2* network; see page 122.

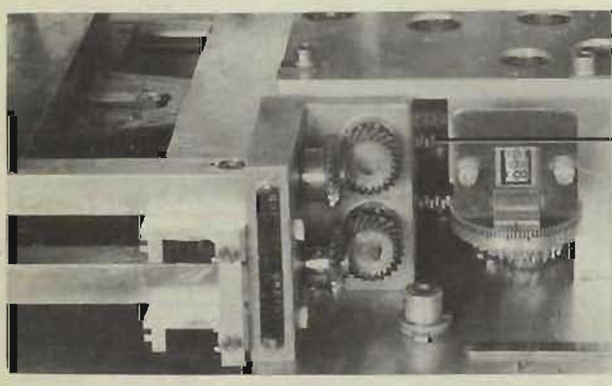
Check the *B'gr* input by comparing the *B'gr* dial reading with the value given in the intermediate quantities. If the dial reading does not agree with the value given, check the *B'gr* network; see page 106.

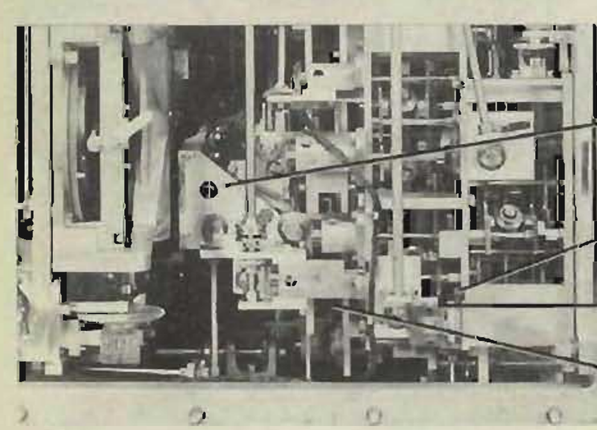






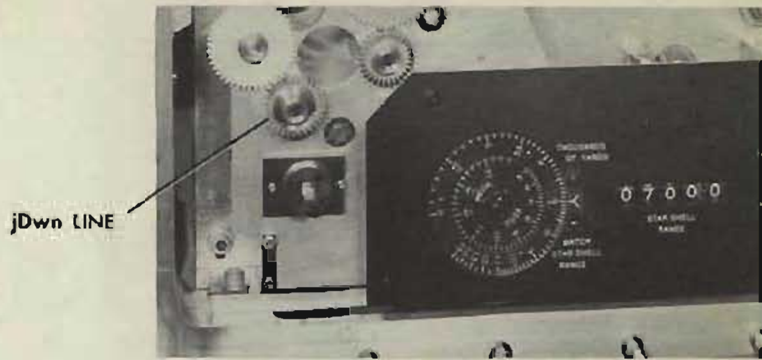
Check the *WrD* + *KRdBs* input. If *B'gr* is correct, the *WrD* + *KRdBs* line up to the *WrD* + *KRdBs* counter in the Computer Mark 1 will also be correct. Check the *WrD* + *KRdBs* counter in the star shell computer. If the counter reading does not agree with the value in the intermediate quantities, check the counter in the star shell computer against the counter in the Computer Mark 1. If the counter readings do not agree, check A-230* and the *WrD* + *KRdBs* follow-up. If the two counter readings agree, but are not at the value given in the intermediate quantities, check A-229* and A-6.





*These adjustments are in the Computer Mark 1. All others are in the star shell computer.

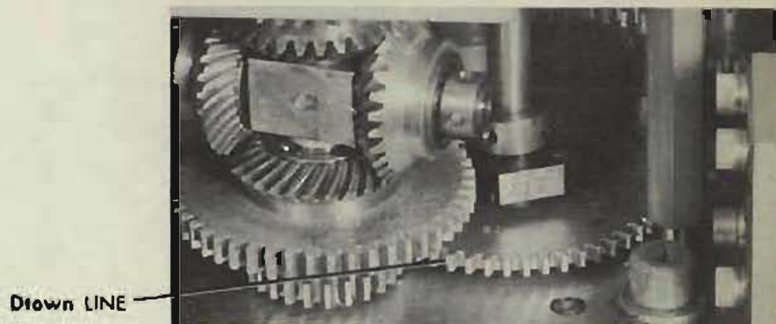
Check the *jDwn* input by checking A-5.



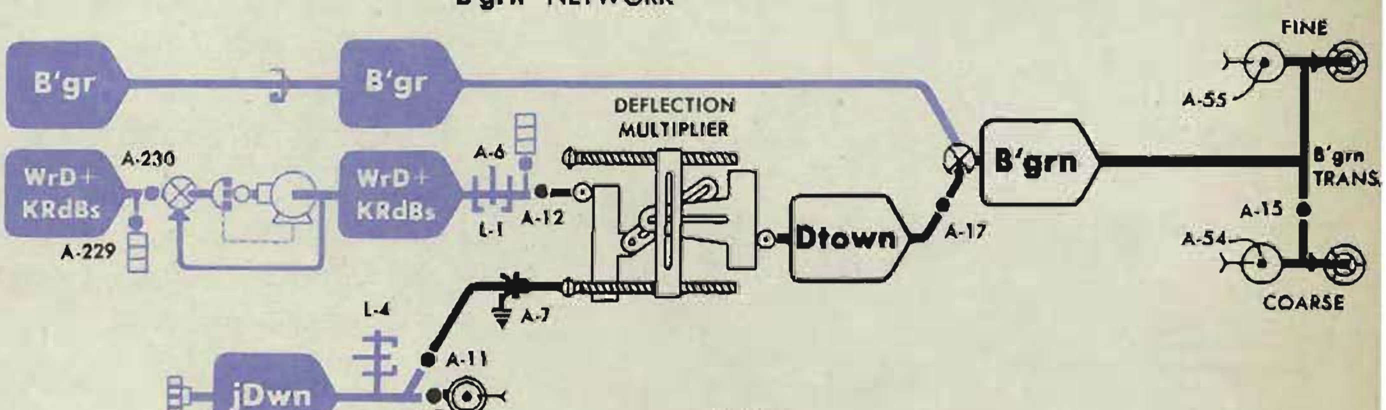
Checking the network

When the network inputs are correct, check A-12, A-11, A-17, A-15, A-54 and A-55.

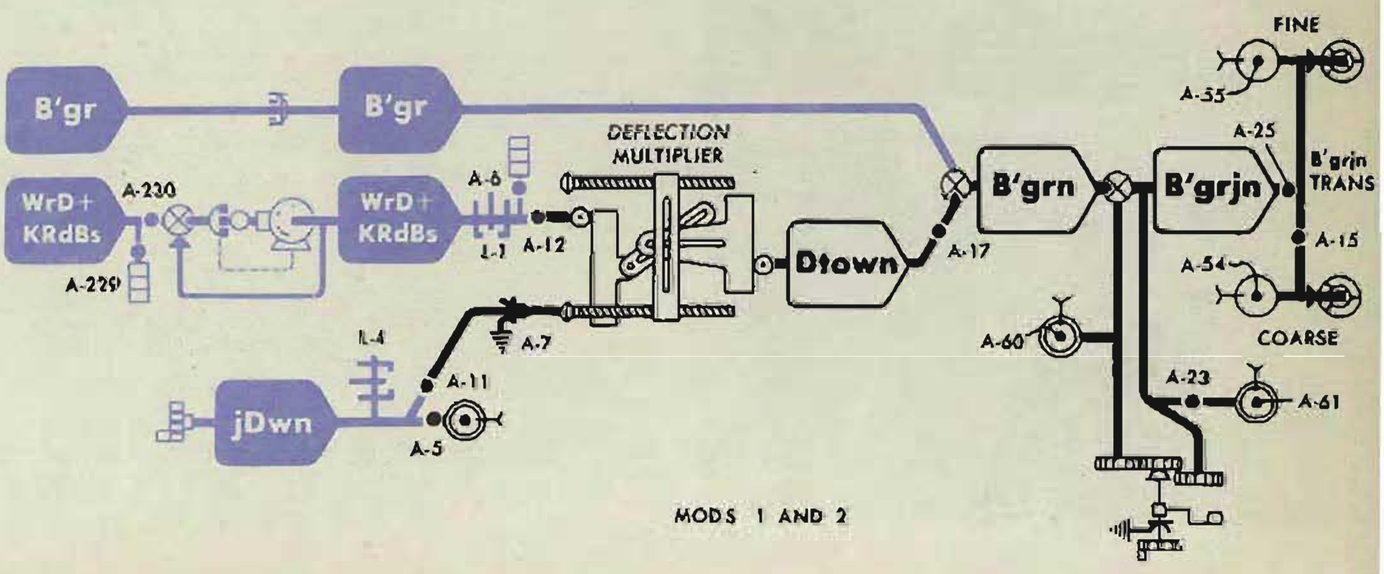
For Mods 1 and 2, also check A-60, A-61, and A-23.



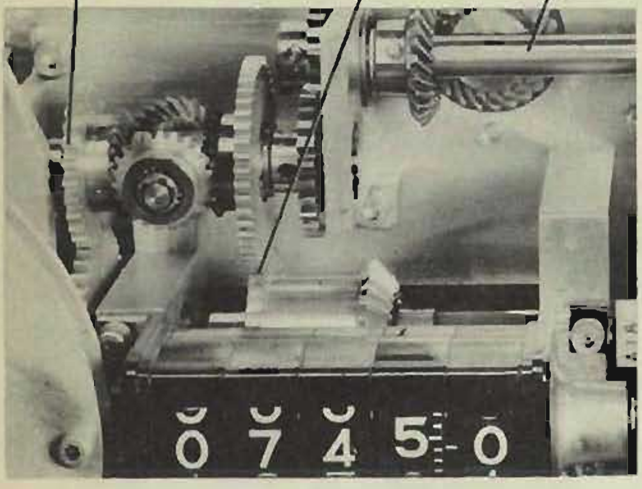
B'grn NETWORK

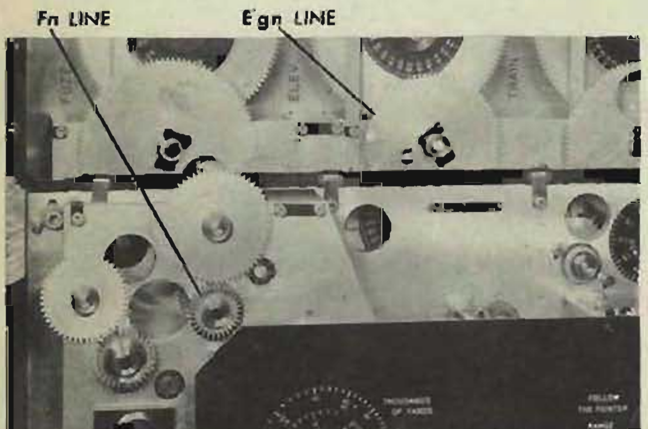


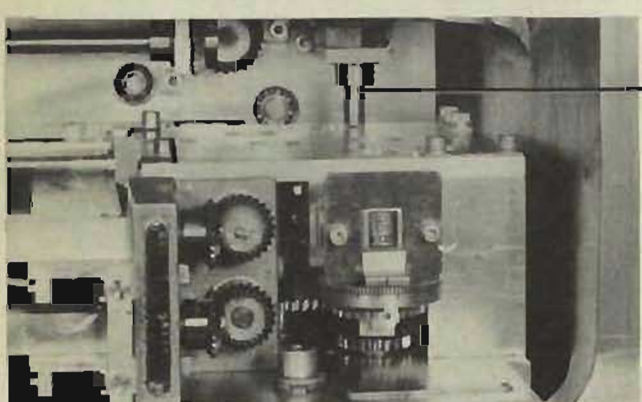
MOD O



MODS 1 AND 2







ERRORS IN E'gn

Check the *R2* input by comparing the reading on the computer *R2* counter with the value given under intermediate quantities. If the counter reading does not agree with the value given, check the *R2* network; see page 122.

Check the *E'g* input by comparing the reading on the computer *E'g* dials with the *E'g* value given in the intermediate quantities. If the dial reading does not agree with the value given, check the *E'g* network; see page 107. When the dial reading is correct, check A-231.*

When the *R2* and *E'g* inputs are correct, but *E'gn* is in error, check the *Rjn* input by comparing the reading on the star shell range counter with the value given in the intermediate quantities. If the counter reading does not agree with the value given, check A-2 and A-18. Check that A-1 is tight.

Check the *jDwn* input by checking A-5.

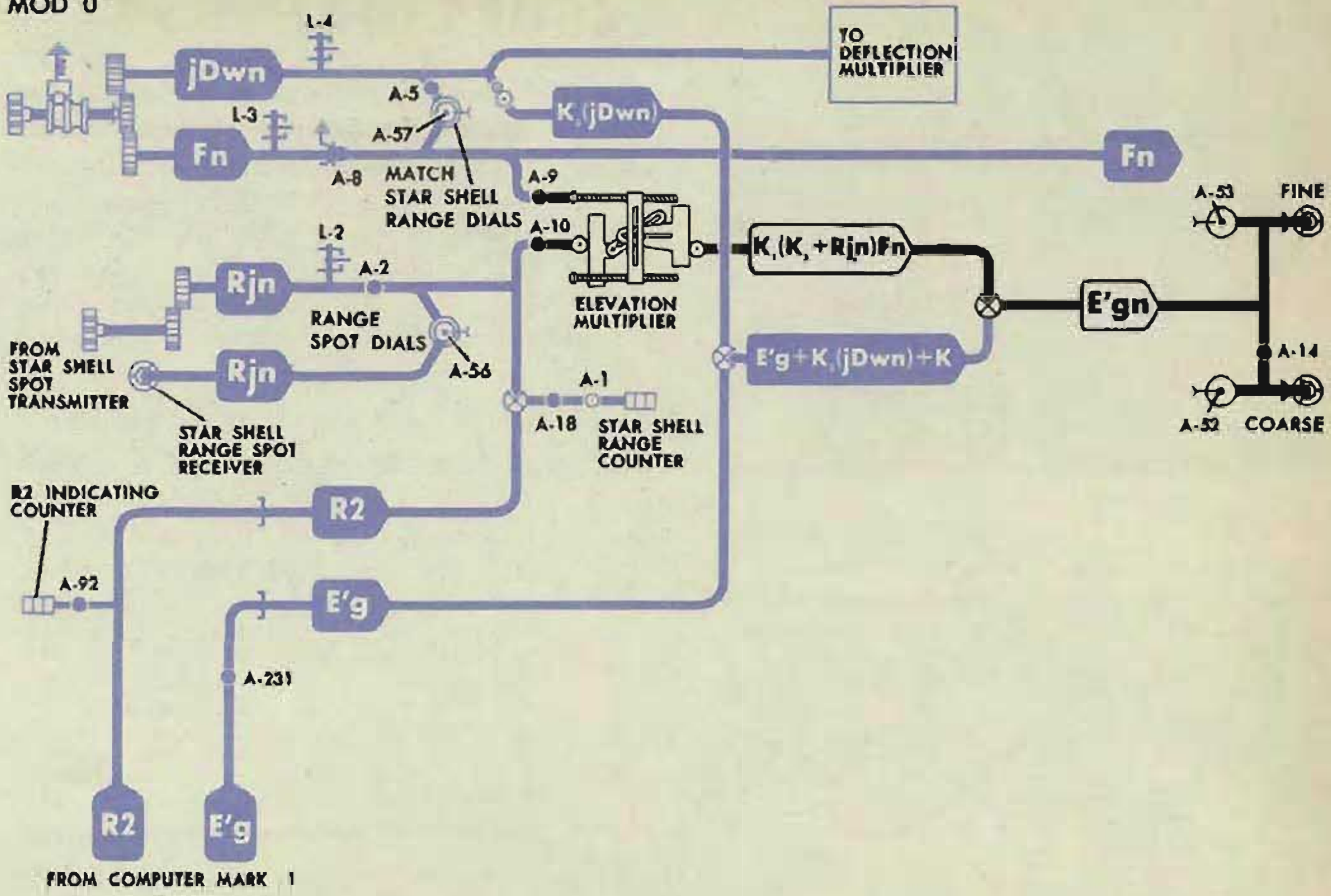
Check the *Fn* input by checking A-57.

When all the inputs are correct, check A-9, A-10, A-14, A-52 and A-53. For Mods 1 and 2, also check A-58, A-59 and A-22.

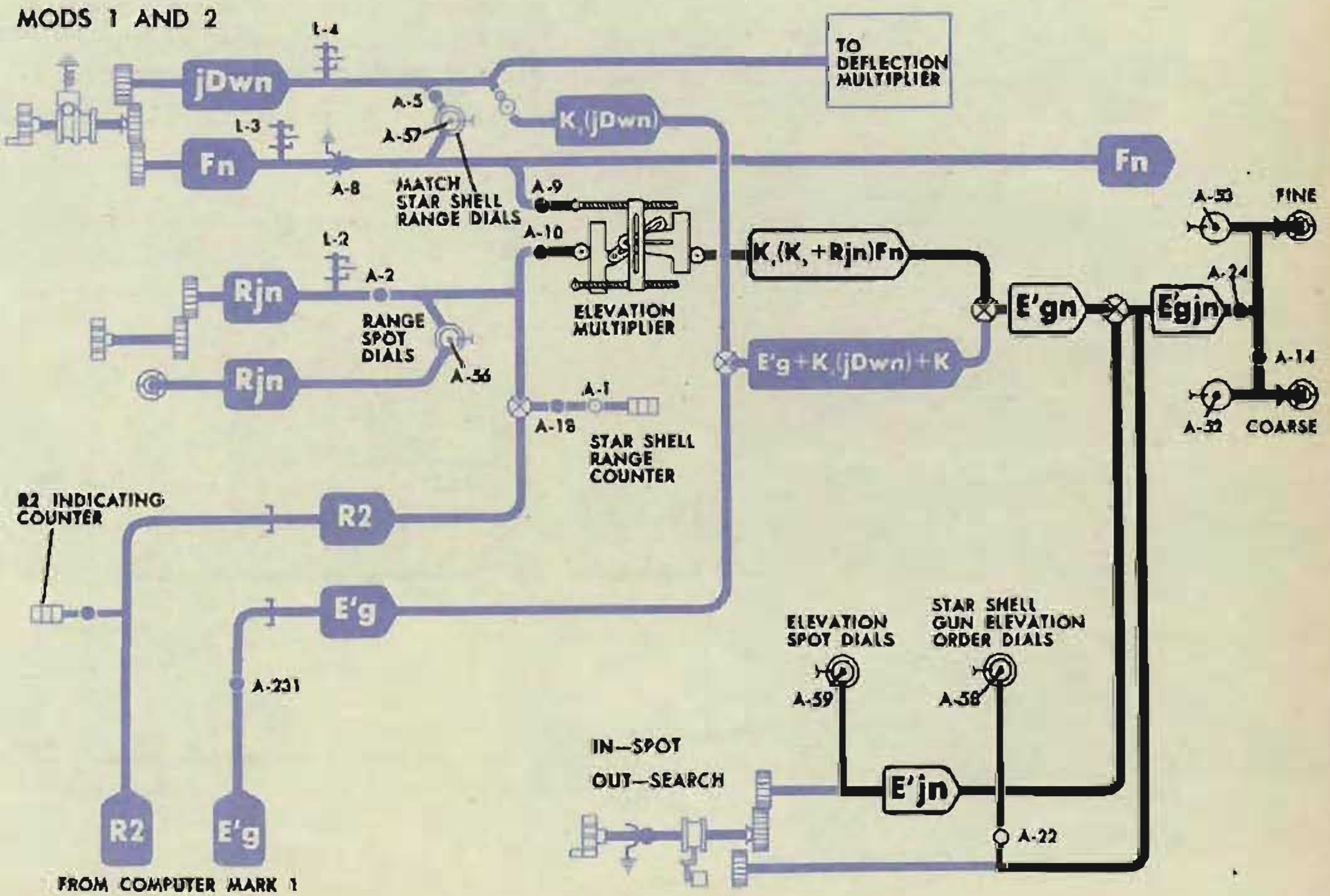
*This adjustment is in the Computer Mark 1. All others are in the star shell computer.

STAR SHELL GUN ELEVATION NETWORK

MOD 0



MODS 1 AND 2

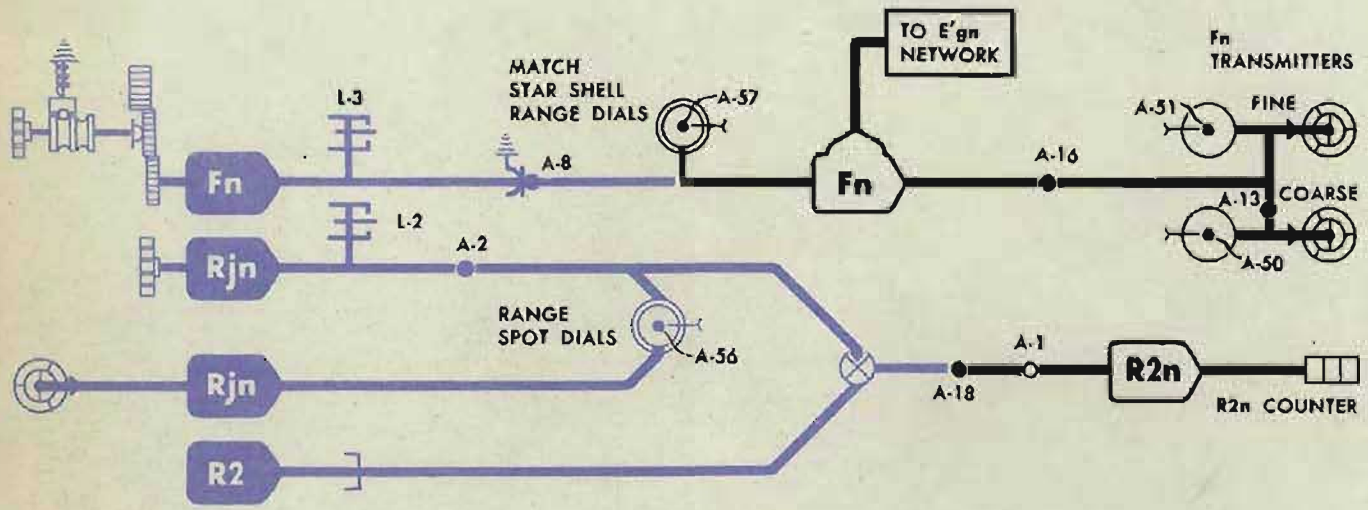


ERRORS IN Fn

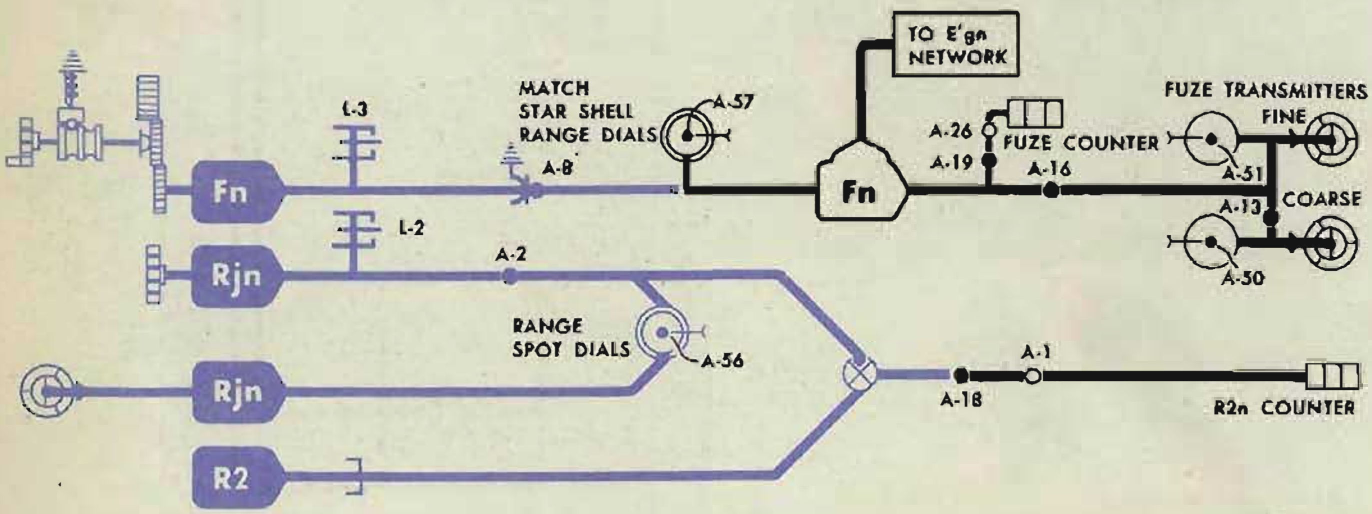
The *R2* input to the *Fn* network should be checked and corrected before any adjustments are made within the network.

Check the *R2* input by comparing the reading on the *R2* indicating counter with the *R2* intermediate quantity. If the reading on the *R2* indicating counter does not agree with the *R2* value given, check the *R2* network; see page 122.

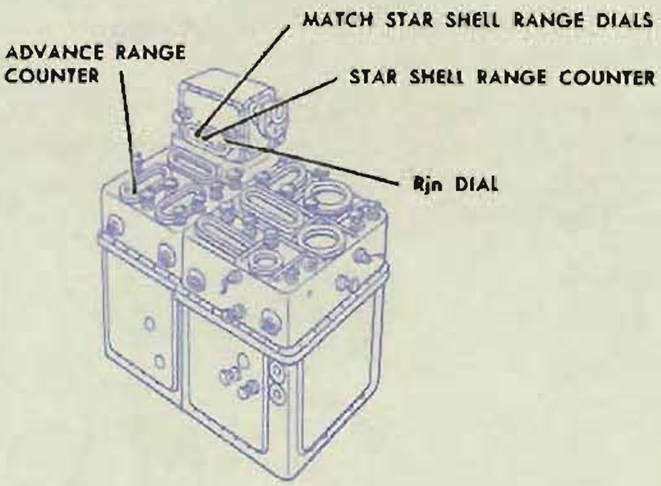
STAR SHELL FUZE NETWORK IN MOD 0



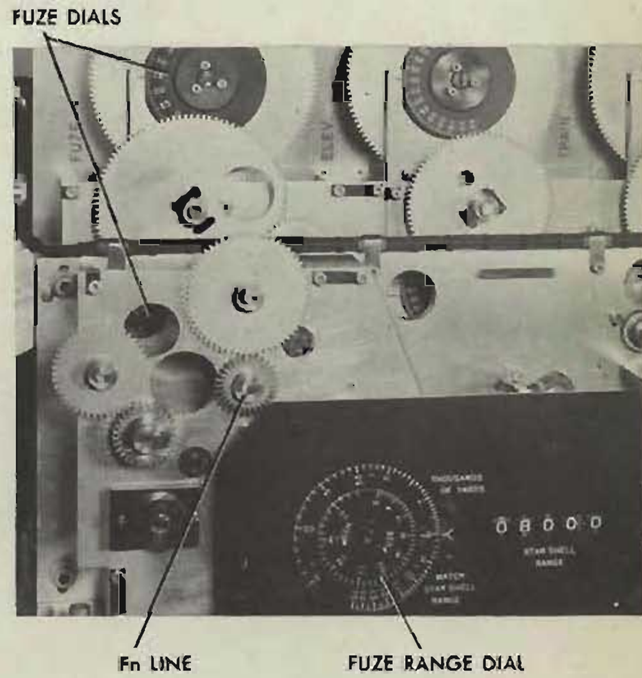
STAR SHELL FUZE NETWORK IN MODS 1 AND 2



Check the $R2n$ input by comparing the reading on the $R2n$ counter with the $R2n$ intermediate quantity.

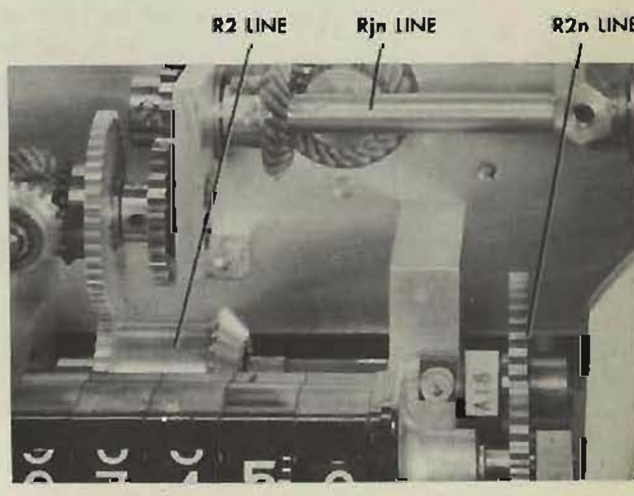


Check the Rjn input by checking A-2.



If $R2n$ is in error, check A-18, and check that A-1 is tight.

If both $R2$ and $R2n$ are correct, check A-16, A-57, A-13, A-50 and A-51.



For Mods 1 and 2, also check A-19 and A-26.

B TEST ANALYSIS

In the following analysis, the word "error" refers to *rate error* derived from the B test results.

B test analysis provides a method of finding and correcting B test errors. Before they can be analyzed and corrected, a complete set of B tests should be run. To find the cause of error, the type of error should first be determined.

TYPES OF ERRORS

Large errors

Large errors may be considered as those errors that exceed the allowable maximum. Their existence usually indicates that an adjustment has changed, or that mechanical trouble exists. The cause should be found and corrected.

Small errors

Small errors may be considered as those errors that exceed the allowable average, but are within the allowable maximum. They may become sizable in the course of normal operation and usually can be reduced by refining the vernier adjustments. If these errors increase slowly over a period of time, they are probably caused by wear in the computer. To reduce those caused by wear, it is usually necessary to reduce the lost motion in the units and the shaft lines.

Unstable errors

Unstable errors may be of two types. In one type, the error varies for several setups of the same problem. This is usually caused either by inaccurate problem setups, or by excessive lost motion or binding in the gearing or integrator units. In the other type, the error varies for consecutive time intervals of the same problem setup. This variation is usually caused by mechanical defects in a unit or by a generated quantity backing out through some other line.

SIGN OF ERRORS

Refer to page 30 for computing error.

Problems 1, 12, and 23 are *zero rate* problems; problems 2 to 6, 13 to 17, and 24 to 28 are decreasing problems; and problems 7 to 11, 18 to 22, and 29 to 33 are increasing problems. Examination of the input values will show the nature of each problem.

If the generated output is too much, the problem is said to be too fast; if the output is too little, the problem is too slow.

To determine whether a problem is too fast or too slow, check the direction of rotation of the fine generated dial. During increasing problems, range and elevation turn clockwise, while bearing turns counterclockwise. During decreasing problems, the fine generated dials turn in the opposite direction.

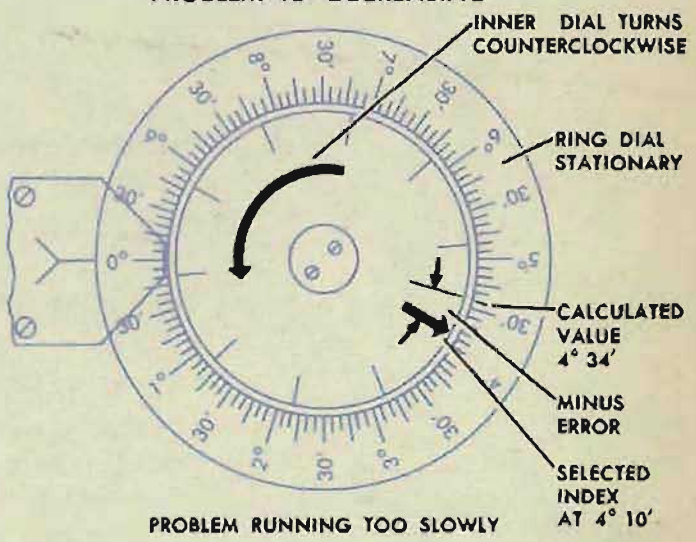
In elevation and bearing problems, if the selected index of the inner dial has turned beyond the calculated value on the fine ring dial, the problem is running too fast. If the index has not reached the calculated value, the problem is running too slowly.

Converting plus or minus to fast or slow may seem confusing, since the graduated ring dial is stationary during the elevation and bearing B tests. A study of the sketches, however, will show that: Plus errors in decreasing elevation and bearing problems and minus errors in increasing problems indicate that the problems are running too fast. Minus errors in decreasing problems and plus errors in increasing problems indicate that the problems are running too slowly.

Since the generated range dials are graduated, and both range dials turn during B tests, it can easily be determined whether range problems are fast or slow.

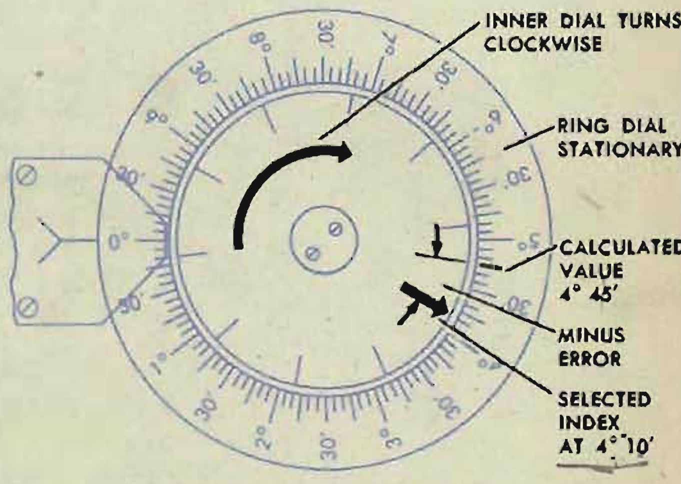
ELEVATION DIALS

PROBLEM 15—DECREASING



PROBLEM RUNNING TOO SLOWLY

PROBLEM 18—INCREASING



PROBLEM RUNNING TOO FAST

CAUSES OF ERRORS

Very large errors may be caused by a defective follow-up or an incorrect relative motion rate. The follow-ups and relative motion rates can be checked by running A test problems and making the relative motion component solver unit check test. Other errors are usually caused by incorrect adjustments or mechanical defects in the integrator group.

CORRECTING THE ERRORS

When the cause of the error is found, the necessary repairs and readjustments should be made. If no repairs are necessary, the vernier adjustments should be refined to give the proper integrator outputs. The vernier adjustments are usually made by the trial and error method and may require several refinements to obtain satisfactory results.

If most of the adjustments of the bearing and elevation integrator group are upset, or any units have been removed for repairs and reinstalled, either of the two following procedures may be used:

1. Follow the complete adjustment of the integrator group as given at the end of this chapter, page 160.
2. First, check and readjust if necessary: A-233, A-152, A-155, A-250, A-146, and A-140.
   Second, run the T/cR and (T/cR) sec E integrator unit check tests, page 212.
   Third, run the special bearing and elevation integrator problems given in this chapter on page 159.

READING THE DIALS

The analysis of test error is based on the assumption that the errors have been calculated from proper dial readings. Reading the dials correctly in elevation and bearing B tests requires an understanding of the relation between the inner and outer dials during the tests.

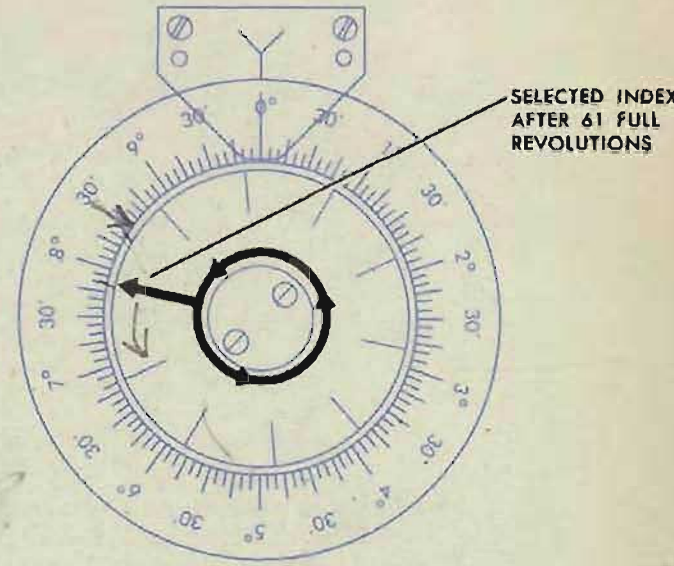
Only the *inner fine* generated elevation and bearing dials turn during B tests. The observed elevation and bearing dials do not turn. The calculated values listed on the record form for problem results are actually $360° - cE$ and $360° - cBr$. Values are specified in this way because it is convenient to read rotation of the inner dial directly against the graduated ring dial for all problems.

To obtain the full reading of $360° - cE$ or $360° - cBr$, it is necessary to count the revolutions of the fine dial for some time interval, then compare with the rate, dE or dB, for the same time interval. This is found from the deg./min. value for the problem, given on the problem setup sheet. Each revolution of the fine cE or cBr dial counts 10°. If the number of revolutions checks, the generated rate is correct within 10°. Then the full instrument reading will be the actual reading of the fine inner dial against the outer dial, preceded by the tens and hundreds of degrees of the calculated value for $360° - cE$ or $360° - cBr$.

FOR EXAMPLE

Consider problem 33, in which the calculated value is 108°24′ at the end of the first one-minute interval. The value of *dB* is given as +611.6 deg./min., so the fine inner dial should turn slightly over 61 revolutions in the one-minute period. Assume that the selected index mark on the *cBr* dial has stopped at the reading 7°50′, as shown in the sketch, after making 61 full revolutions. Then the generated rate is correct within 10°, and the instrument reading is 7°50′ preceded by the tens and hundreds of degrees of the calculated reading, or 107°50′. The error will be +34′. In this case the problem is too fast.

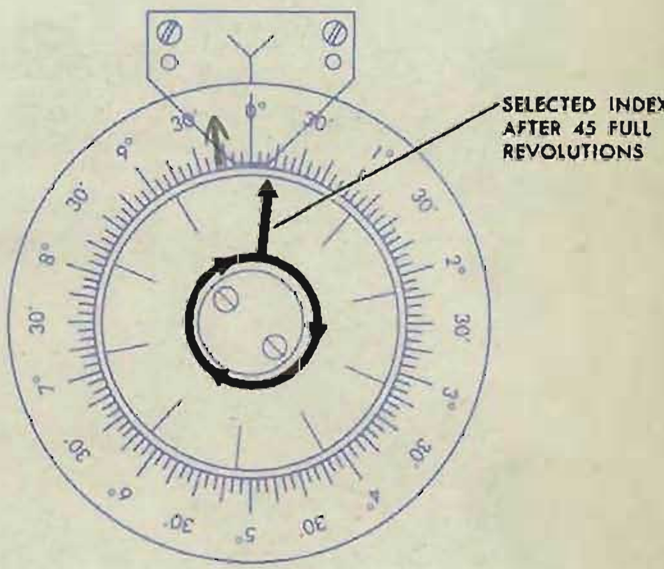
FINE BEARING DIALS



PROBLEM 33

As another example, consider problem 25, in which the calculated value is 89°42′ at the end of the first one-minute interval. The value of *dB* is given as −449.7 deg./min. Assume that the inner dial has made slightly over 45 revolutions and stopped at 0°10′, as shown in the sketch. Although the number of revolutions does not check, watching rotation of the dial will show that completion of the 45th revolution is less than 1° error in generation over the 44.97 revolutions called for by the rate, *dB*. Therefore the generated rate is still correct within 10°. But the quantity 360° −*cBr* has passed through 90°. Therefore the total instrument reading to be recorded is 90°10′. The error will be +28′. This problem is also too fast.

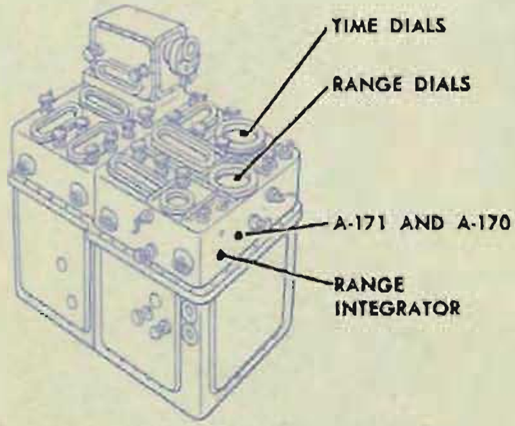
FINE BEARING DIALS

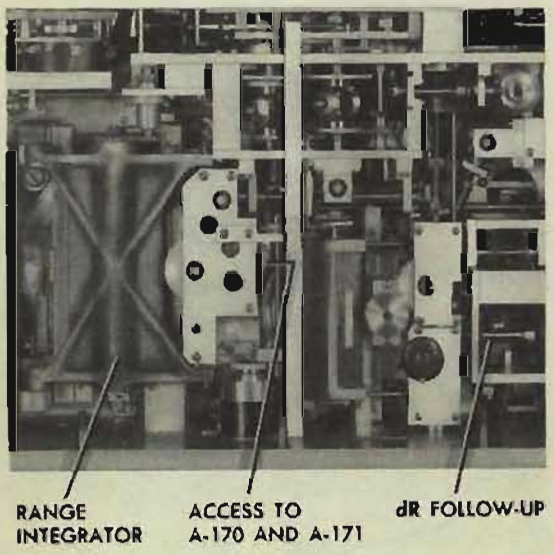


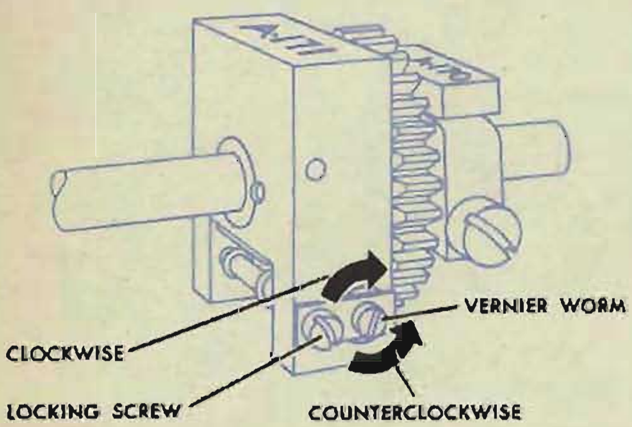
PROBLEM 25

The full readings of 360° − *cE* are obtained in a similar manner.

CORRECTING ERRORS IN RANGE B TESTS







RANGE VERNIER

Large errors

Large errors are usually caused by mechanical defects or an incorrect value of *dR*. Check the *dR* follow-up. Refer to page 559 and also to OP 1140A.

Check A-163.

Check the *dR* input to the range integrator. See *Checking the dR Network*, page 134.

Errors of like sign in all problems

If the *dR* input has been checked and found correct, and still all errors have like signs, the carriage of the range integrator is incorrectly positioned. Check that A-170 is tight and does not slip.

Readjust A-171 as follows:

Loosen the locking screw on A-171.

If all the errors are *plus*, turn the vernier worm in a *counterclockwise* direction.

If all the errors are *minus*, turn the vernier worm in a *clockwise* direction.

Tighten the locking screw on A-171 and recheck. Continue the adjustment until the *plus* errors balance the *minus* errors.

Errors of one sign in decreasing problems and errors of the opposite sign in increasing problems

Problems 2 through 6 are decreasing problems, and 7 through 11 are increasing problems.

If the errors for problems 2 through 6 are *minus* and 7 through 11 are *plus*, all problems are running *too fast*.

If the errors for problems 2 through 6 are *plus* and 7 through 11 are *minus*, all problems are running *too* slowly.

If all problems are too fast or all problems are too slow, the speed pin of one or more of the relative motion component solvers may be incorrectly positioned. Make the relative motion component solvers check test, page 190. Check the A test results.

Excessive error at high elevation

In problems 4, 5, 7, and 8, a high value of elevation is used. If the rate errors in these problems are especially large, the speed pin of the *dH* component solver may be incorrectly positioned. If only problem 7 has a large error, the vector gear of the *dRh* component solver may be incorrectly positioned. Make the relative motion component solvers check test, page 190. Check the A test results.

Excessive error at low elevation

In problems 2, 3, and 6, a low value of elevation is used. If the rate errors in these problems are especially large, the *dRh* component solver speed pin may be in error. Make the relative motion component solvers check test, page 190. Check the A test results.

Unstable errors

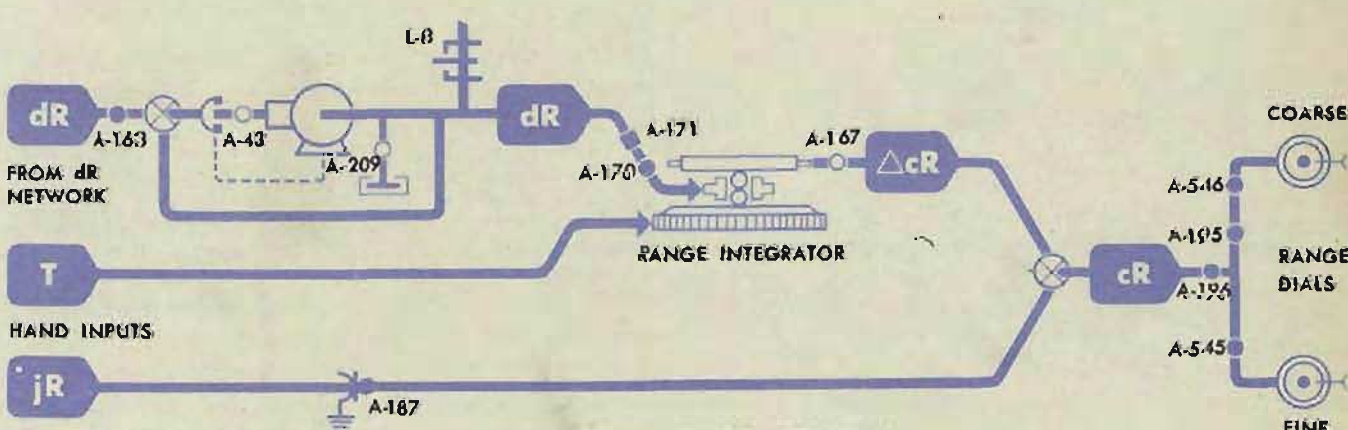
Unstable errors are usually caused by one of the following mechanical defects:

A faulty range integrator

Check the range integrator for mechanical defects. Refer to page 557, and also to OP 1140A.

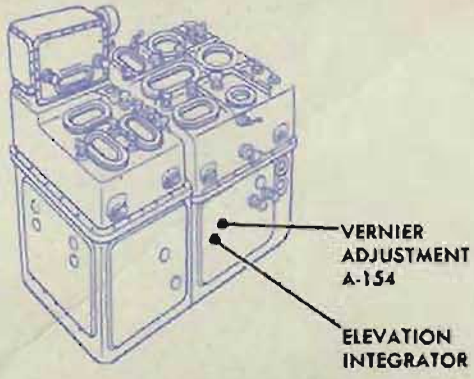
Sticking or binding in the dR line

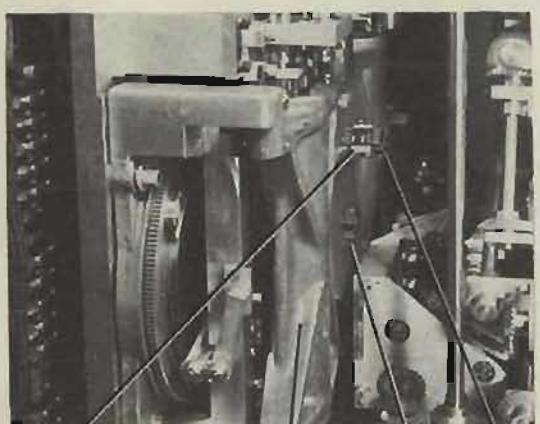
Check the *dR* follow-up, shaft line, and gearing under cover 1. Refer to page 559, and also to OP 1140A.



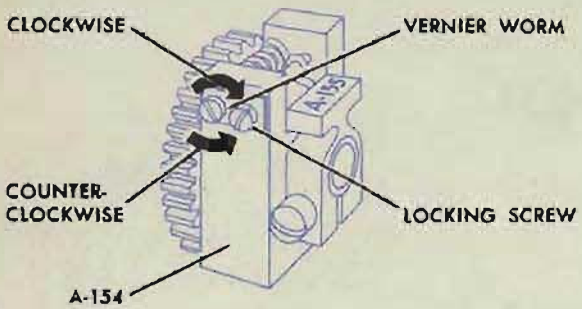
RANGE INTEGRATOR NETWORK

CORRECTING ERRORS IN ELEVATION B TESTS





VERNIER ADJUSTMENT A-154 ELEVATION INTEGRATOR CLAMP A-211 CLAMP A-155



Large errors

Large errors are usually caused by mechanical defects.

Check the *RdE* and integrator networks for mechanical casualties.

Make the *T/cR* integrator check test. See page 212.

Check the *RdE* follow-up. Refer to page 559, and also to OP 1140A.

Errors of like sign in all problems

If the *RdE* input has been checked and found correct, and still all errors are of like sign, the carriage of the elevation integrator is incorrectly positioned. Check that A-155 and A-211 are tight.

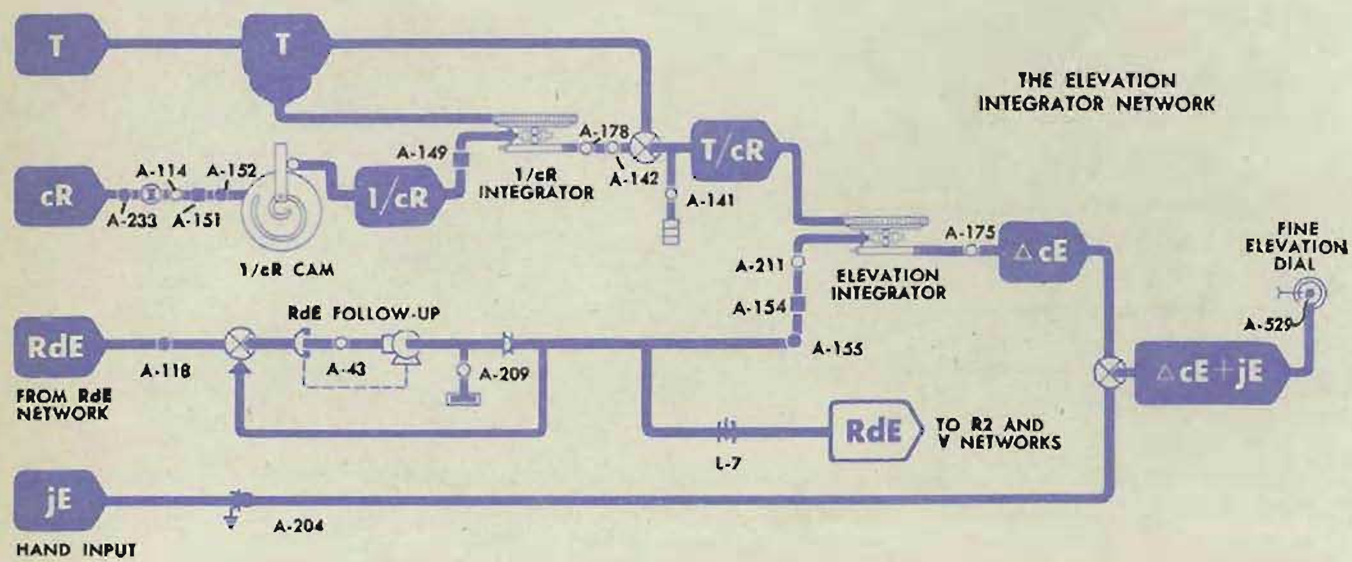
Readjust A-154 as follows:

Loosen the locking screw on A-154.

If all the errors are *plus,* turn the vernier worm in a *clockwise* direction.

If all the errors are *minus,* turn the vernier worm in a *counterclockwise* direction.

Tighten the locking screw on A-154 and recheck.



Errors of one sign in decreasing problems and errors of the opposite sign in increasing problems

Such errors show that all problems are too fast or too slow. These errors may be caused by:

Error in RdE

The cause of error may be in the relative motion group. If there is error in any of the relative motion component solvers, the range B tests and A tests will also show the error. See *Checking the RdE Network*, page 137. Check the A test results.

Error in T/cR

Make the *T/cR* integrator check test, page 212.

The *T/cR* counter readings may be correct in the *T/cR* integrator check test and yet be incorrect for a satisfactory set of B tests. If a record of *T/cR* counter readings for a satisfactory set of B tests has been kept, readjust A-149 to these readings.

If no record has been kept, readjust A-149 as follows:

Loosen the locking screw of A-149.

If all problems run *too slowly*, turn the vernier screw *counterclockwise* to correct a minus error in problems 13 through 17 and a plus error in problems 18 through 22.

If all problems run *too fast*, turn the vernier screw clockwise to correct a plus error in problems 13 through 17, and a minus error in problems 18 through 22.

Tighten the locking screw of A-149 and recheck.

NOTE:

Any adjustment of T/cR will have a greater effect on the bearing B test results than on the elevation B test results.

Excessive errors at short range

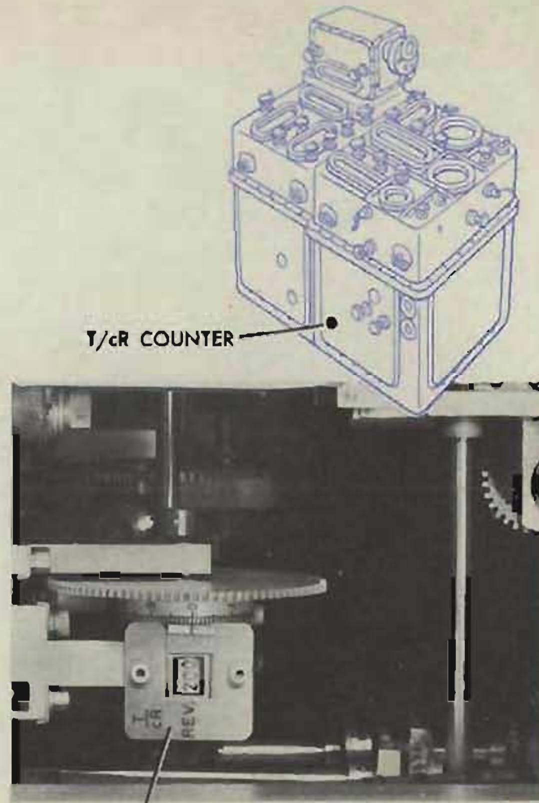
In problems 13, 14, 21, and 22, short-range values are used.

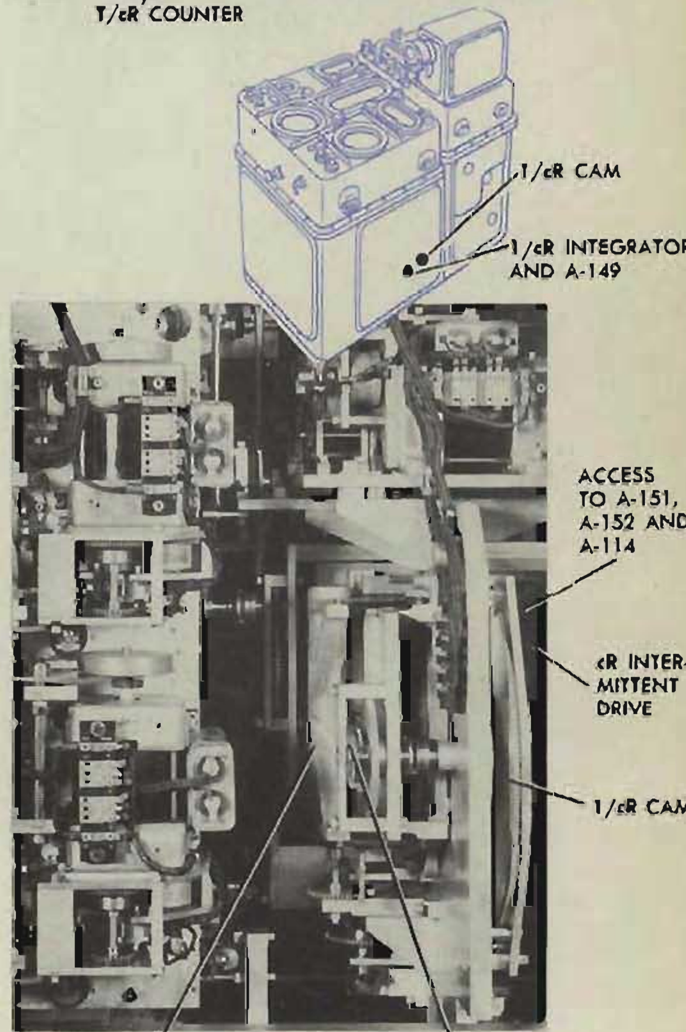
If the rate errors in these problems are especially large, and the rate errors at long or medium range are smaller, or very small:

Check the *cR* intermittent drive, A-233.
Check that A-114 and A-152 are tight.
Readjust A-151.

NOTE:

Any adjustment of A-151 will have a greater effect on the bearing B test results than on the elevation B test results.





Excessive error at low elevation

In problems 12, 16, and 19, low values of elevation are used. If the rate errors in these problems are especially large, the *dH* component solver may be in error. Make the relative motion component solvers check test, page 190. Check the A test results.

Excessive error at high elevation

In all problems except 12, 16, and 19, high values of elevation are used. If the rate errors in these problems are especially large, the speed pin of the *dRh* component solver may be incorrectly positioned. Make the relative motion component solvers check test, page 190. Check the A test results.

NOTE:
An error in the dH *or* dRh *component solver will also show in range B tests.*

Unstable errors

Unstable errors are usually caused by one of the following mechanical defects:

A faulty elevation integrator

Check the elevation integrator for mechanical defects. Refer to page 557, and also to OP 1140A.

A faulty 1/cR integrator

Check the 1/*cR* integrator for mechanical defects. Refer to page 557 and also to OP 1140A.

Sticking or binding in the RdE line

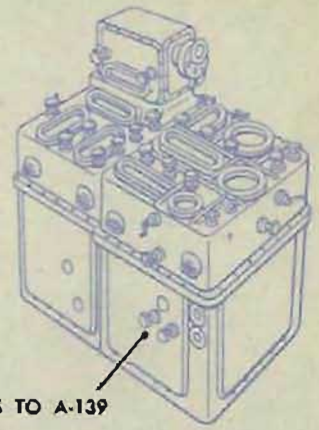
Slight sticking in the input gearing of the *RdE* follow-up may cause relatively large errors in all elevation B test problems. Check the *RdE* follow-up, shaft line, and gearing. Refer to page 559, and also to OP 1140A.

Sticking or binding in the cR or 1/cR line

Check the *cR* shaft line and gearing, the *cR* intermittent drive and shock absorber, the 1/*cR* cam and gearing, and the vernier assemblies for mechanical defects. Refer to page 552, and also to OP 1140A.

NOTE:
Any mechanical defect in cR *or 1/*cR *will cause a larger error in bearing B tests.*

CORRECTING ERRORS IN BEARING B TESTS



Large errors

Large errors are usually caused by mechanical defects.

Check the *RdBs* follow-up. See page 559, and also OP 1140A. Make the *T/cR* and (*T/cR*) sec *E* integrator check tests, page 212. If no mechanical defects are found, check that all assembly clamps and adjustment clamps in the integrator group are tight. Check assembly clamps A-251, A-176, A-143, A-177, A-114, A-178, and A-142. Check adjustment clamps A-250, A-146, A-140, A-233, and A-152.

Errors of like sign in all problems

If all errors are of like sign, the carriage of the bearing integrator is incorrectly positioned. This position error may be caused by:

Error in the RdBs follow-up

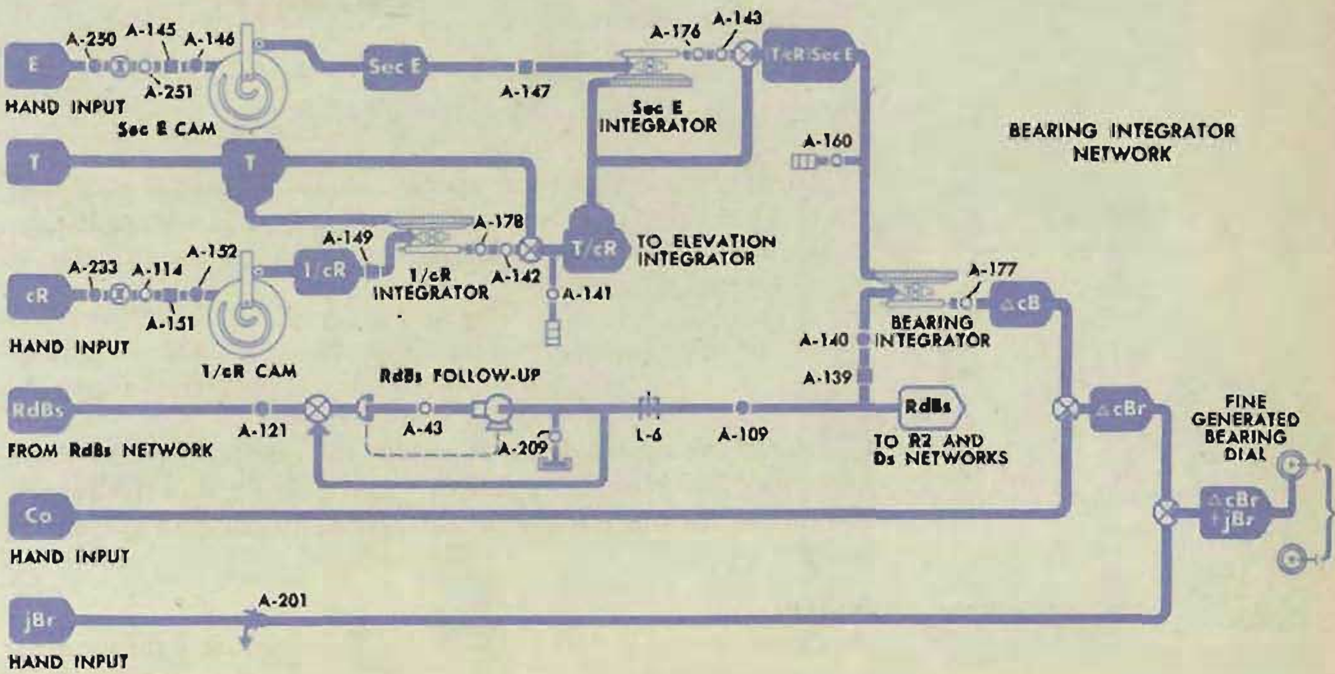
Check A-121.

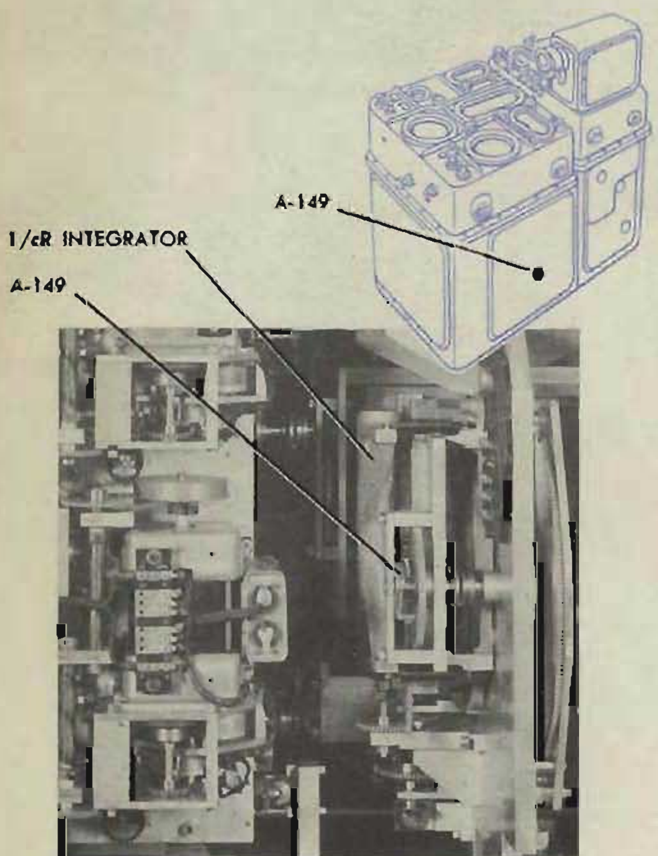
Check the *RdBs* follow-up. See page 559 and OP 1140A.

Slipping in the RdBs line

The *RdBs* line may run into limit stop L-6 so fast that the *RdBs* line stops with a jolt. This sudden stop may cause slipping in the line. Check A-109 and A-140; then run problem 23 and refine A-139.

If the error in problem 23 is *plus*, turn the vernier screw *clockwise*. If the error is *minus*, turn the vernier screw *counterclockwise*. If the line continues to slip after tightening A-109 and A-140, check the shaft lines. Refer to OP 1140A.





Errors of one sign in decreasing problems and errors of the opposite sign in increasing problems

Such errors show that all problems are too fast or too slow. This may be caused by an error in *RdBs* or an error in (*T*/*cR*) sec *E*.

Error in RdBs

The speed pin of the ship component solver or the target component solver may be incorrectly positioned. This will cause all problems to run either too fast or too slow. If all problems are too slow, the vector gear of either the ship component solver or the target component solver may be incorrectly positioned. Refer to *Checking the RdBs Network*, page 137. Check the A test results.

Error in (T/cR) sec E

First, run the (*T*/*cR*) sec *E* integrator check test. Refer to page 215. If all readings in this test are either too slow or too fast, readjust A-147 as follows:

Loosen the locking screw of A-147. If all readings are too slow, turn the vernier screw *counterclockwise*. If all readings are too fast, turn the vernier screw *clockwise*. Tighten the locking screw of A-147 and recheck. Continue the adjustment until the check test errors are at a minimum.

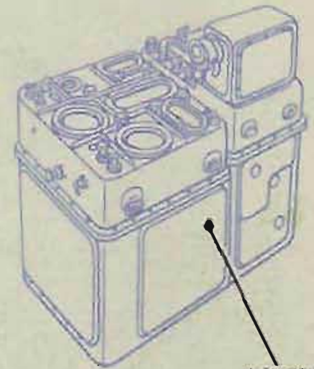
Rerun the bearing B tests. If the same type of error still exists, there may be an error in *T*/*cR*.

Run the *T*/*cR* integrator check test. Refer to page 212. If all readings in this test are either too slow or too fast, readjust A-149 as follows:

Loosen the locking screw of A-149. If all readings are too slow, turn the vernier screw *counterclockwise*. If all readings are too fast, turn the vernier screw *clockwise*.

Tighten the locking screw of A-149 and recheck. Continue the adjustment until the check test errors are at a minimum.

NOTE:
Any adjustment of A-149 will also affect the elevation B test results.



Rerun the bearing B tests. The results may not be entirely satisfactory even though the T/cR and (T/cR) sec E check test errors have been brought to a minimum. If a record has been kept of the proper counter readings for a satisfactory set of B tests, readjust A-147 and A-149 to these readings. If no record has been kept, readjust A-147 slightly, noting the effect on the B test results. Slight readjustment of A-149 may also be necessary to correct this type of error.

Large error at short range

In problems 24, 25, and 32, short range values are used. If the rate errors in these problems are especially large, and the rate errors in other problems with medium or long-range values are smaller, there may be an error in the $1/cR$ cam adjustment.

If a record of T/cR counter readings for satisfactory B tests has been kept, readjust A-151 to these counter readings.

If no record has been kept, readjust A-151 as follows:

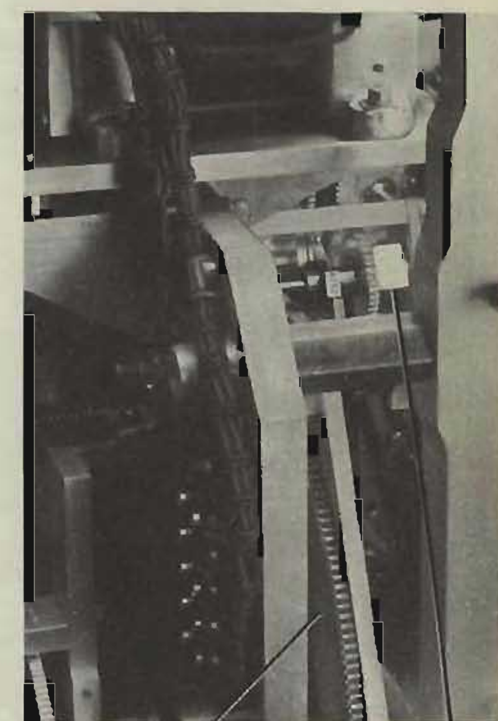
Loosen the locking screw of A-151.

If the problems are slow, turn the vernier screw *counterclockwise* to correct a minus error in problems 24 and 25 and a plus error in problem 32.

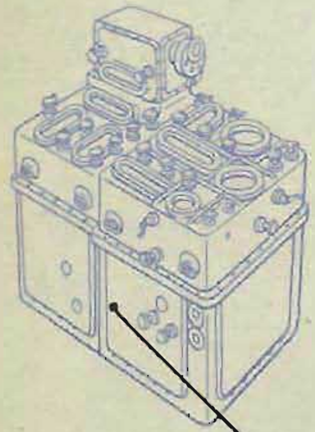
If the problems are fast, turn the vernier screw *clockwise* to correct a plus error in problems 24 and 25 and a minus error in problem 32.

Tighten the locking screw of A-151 and recheck.

NOTE:
Adjustment of A-151 will also affect the elevation B test results.



Large error at high elevation



Problems 24, 28, 32, and 33 have high elevation values. If the rate errors in these problems are especially large, and the rate errors in problems having low elevation values are smaller, there may be an error in the sec *E* cam adjustment.

If a record of (T/cR) sec E counter readings for satisfactory B tests has been kept, readjust A-145 to these counter readings.

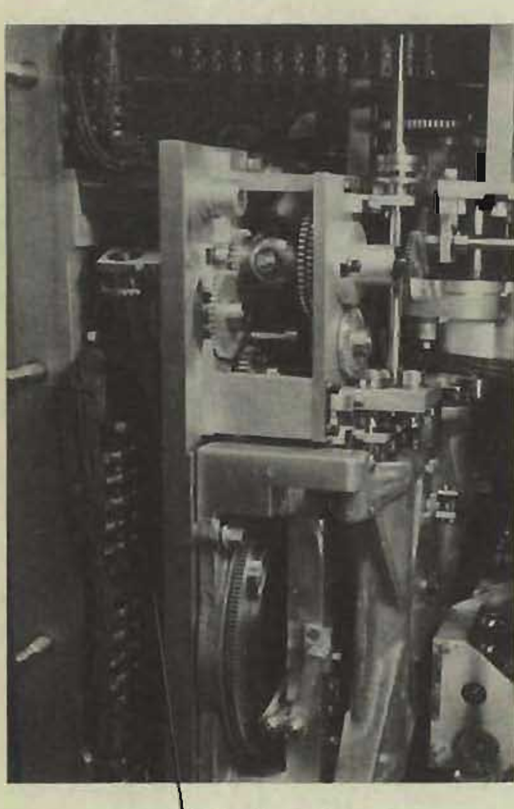
If no record has been kept, readjust A-145 as follows:

Loosen the locking screw of A-145.

If the problems are slow, turn the vernier screw *counterclockwise* to correct a minus error in problems 24 and 28 and a plus error in problems 32 and 33.

If the problems are fast, turn the vernier screw *clockwise* to correct a plus error in problems 24 and 28 and a minus error in problems 32 and 33.

Tighten the locking screw of A-145 and recheck.



SPECIAL ELEVATION and BEARING INTEGRATOR TESTS

PROB. NO.	So KN.	Sh KN.	dH KN.	Br DEG.	A DEG.	E DEG.	cR YARDS	READ DIAL	TRUE RATE DEG./MIN.	ADJUST VERNIER NO.	QUANTITY
1A	0	0	+40	90	90	0	1700	cE	+45.54	A-154	RdE
1B	0	0	-40	90	90	0	1700	cE	-45.54	A-154	RdE
2A	0	40	0	0	90	70	1700	cBr	+133.15	A-139	RdBs
2B	0	40	0	0	270	70	1700	cBr	-133.15	A-139	RdBs
3	25	360	0	0	0	80	20000	cE	+36.69	A-149	1/cR
4	25	360	0	0	0	80	1700	cE	+431.67	A-151	cR
5	20	360	0	90	90	0	2800	cBr	+262.67	A-147	SEC E
6	20	360	0	90	90	70	2800	cBr	+767.99	A-145	E

These tests indicate the effect of vernier adjustments on the integrators. These special problems will be useful during B test analysis to correct integrator errors. Problems 1A and 1B check the elevation integrator. Problems 2A and 2B check the bearing integrator. Problems 3 through 6 check the timing of the T/cR and (T/cR) sec E integrators. For each test, two time intervals are given. Use the short run for the preliminary adjustment, and the long run for the final check.

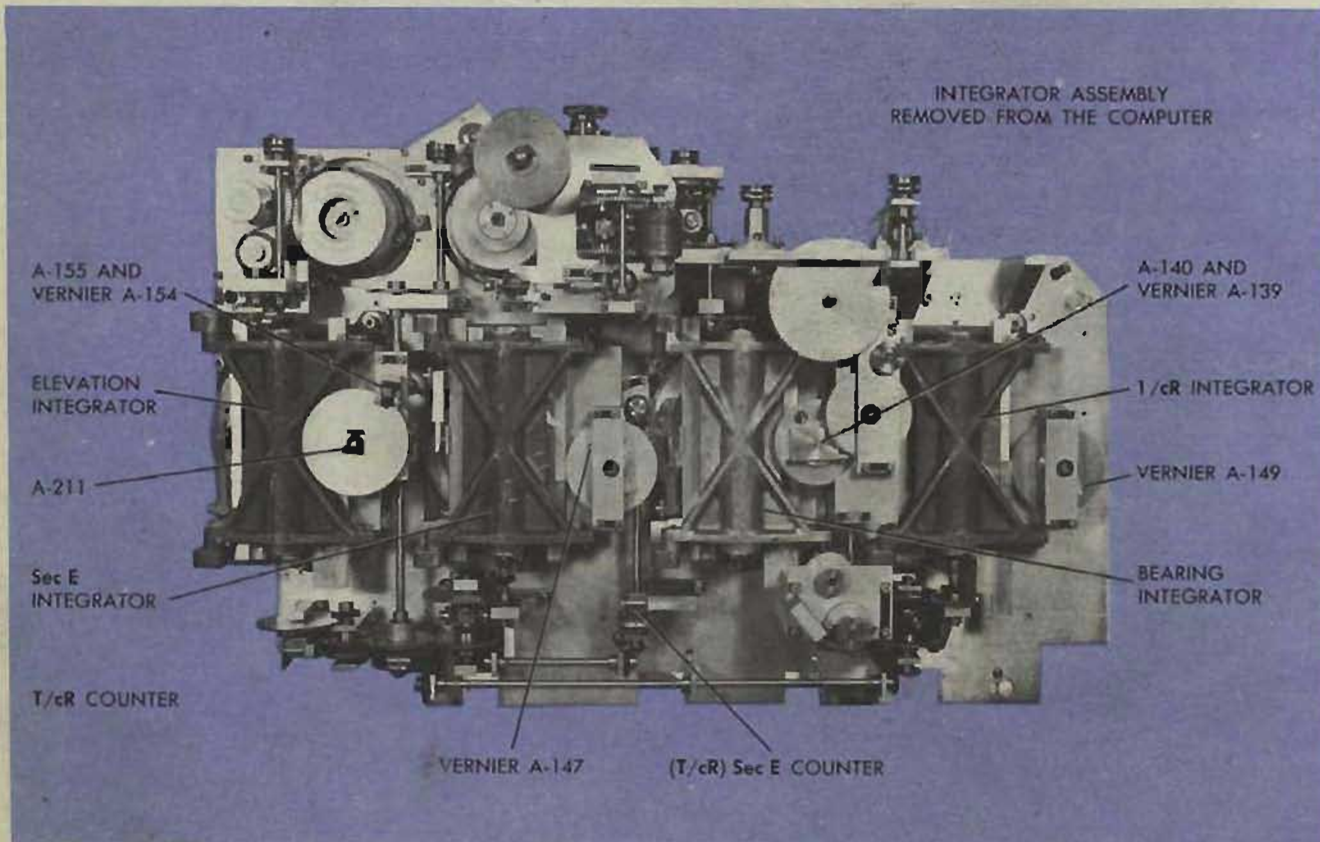
3

How to make the tests

1. Set up the computer for B tests.
2. Run problems 1A, 1B, and 2A, 2B. Adjust the indicated verniers to *balance* 1A with 1B, and 2A with 2B. Balanced errors will have equal magnitude and opposite sign. Disregard the *size* of the balanced errors.
3. Run problems 3 through 6. Make the indicated adjustment to bring the rate error for each to a minimum before proceeding to the next test.
4. After problem 6 is completed, run a full set of the standard elevation and bearing B tests.

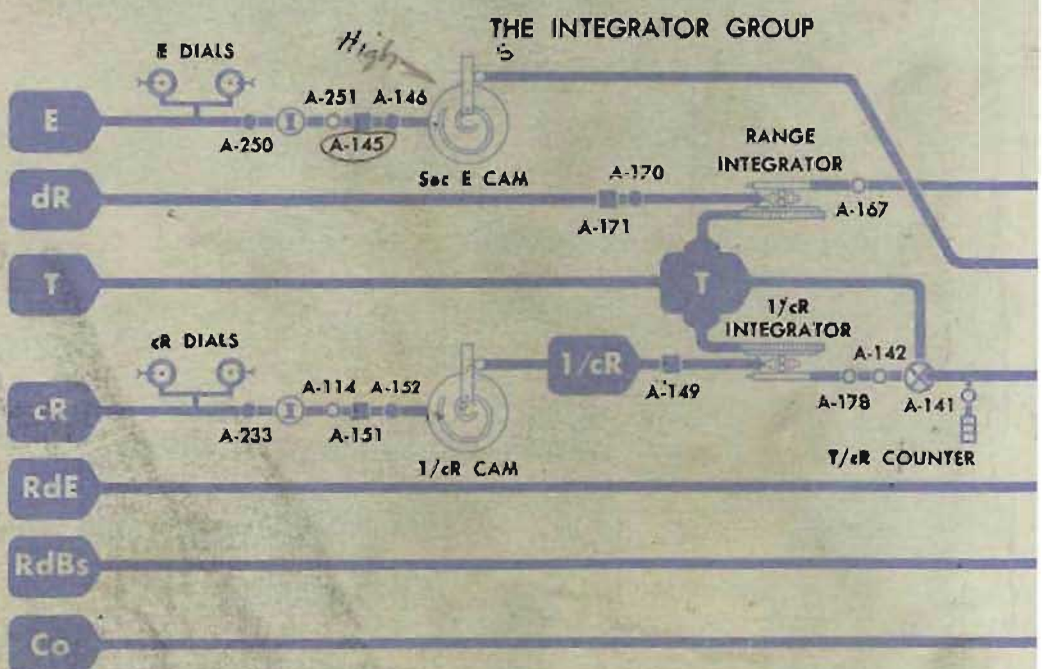
PROB. NO.	TIME SECS.	360°-cE DEG. & MIN. CALC.	READ	ERROR MIN.	RATE ERROR MIN./MIN.	PROB. NO.	TIME SECS.	360°-cBr DEG. & MIN. CALC.	READ	ERROR MIN.	RATE ERROR MIN./MIN.
1A	15	348° 37'				2A	15	326° 43'	7°40'		
	60	314° 28'					60	226° 51'	SLOW		
1B	15	11° 23'				2B	15	33° 17'			
	60	45° 32'					60	133° 09'	132°49	20'	20
3	15	350° 50'				5	15	294° 20'			
	60	323° 18'					60	97° 20'			
4	15	252° 05'				6	15	168° 00'			
	60	288° 20'					30	336° 00'			

COMPLETE ADJUSTMENT OF THE INTEGRATOR NETWORK



If all or most adjustments in the integrator group are upset, or if a unit in the integrator group has been removed and reinstalled, the whole integrator group must be readjusted to give a correct set of B tests.

Use the following adjustment procedure:

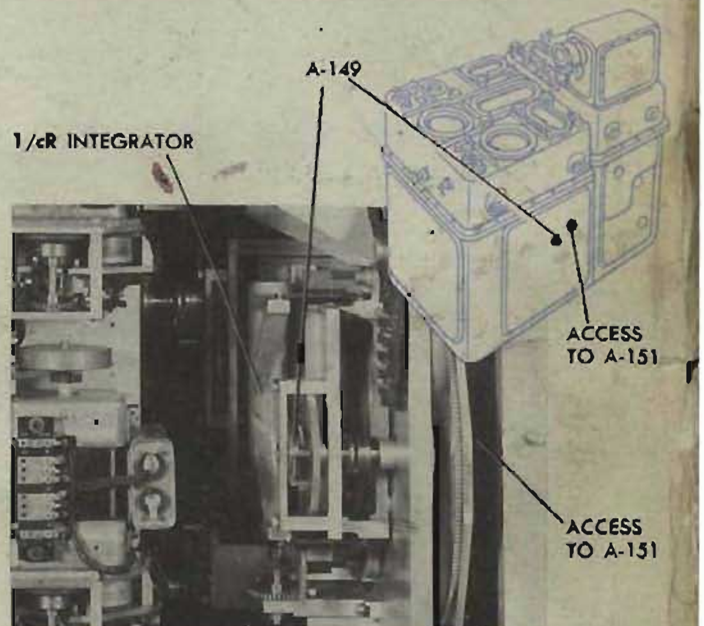


Preliminary adjustment

1. Disconnect the range integrator, or set up a zero range rate. (Refer to page 32.)
2. Adjust the following clamps:
   A-233—*cR* intermittent drive to *cR* dials.
   A-152—1/*cR* cam to *cR* dials.
   A-250—*E* intermittent drive to *E* dials.
   A-146 (or A-210)—sec *E* cam to *E* dials.
   A-155—*RdE* input of elevation integrator to *RdE* line.
   A-140—*RdBs* input of bearing integrator to *RdBs* line.

Refining the adjustment of T/cR

1. Set *cR* at 20,000 yards.
2. Adjust A-149.
   Loosen the locking screw and adjust the vernier screw so that the *T*/*cR* counter makes ~~14.99~~ to ~~15.04~~ revolutions per minute. 29.97
   Turn the vernier screw counterclockwise to increase the integrator output.
   Turn the vernier screw clockwise to decrease the integrator output.
   Tighten the locking screw.
3. Set *cR* at ~~[illegible]~~ yards. 1500 yds
4. Adjust vernier A-151.
   Loosen the locking screw and adjust the vernier screw so that the *T*/*cR* counter makes ~~187.32~~ to ~~187.37~~ revolutions per minute. 399.62
   Turn the vernier screw counterclockwise to increase the integrator output.
   Turn the vernier screw clockwise to decrease the integrator output.
   Tighten the locking screw.
   Recheck A-149.



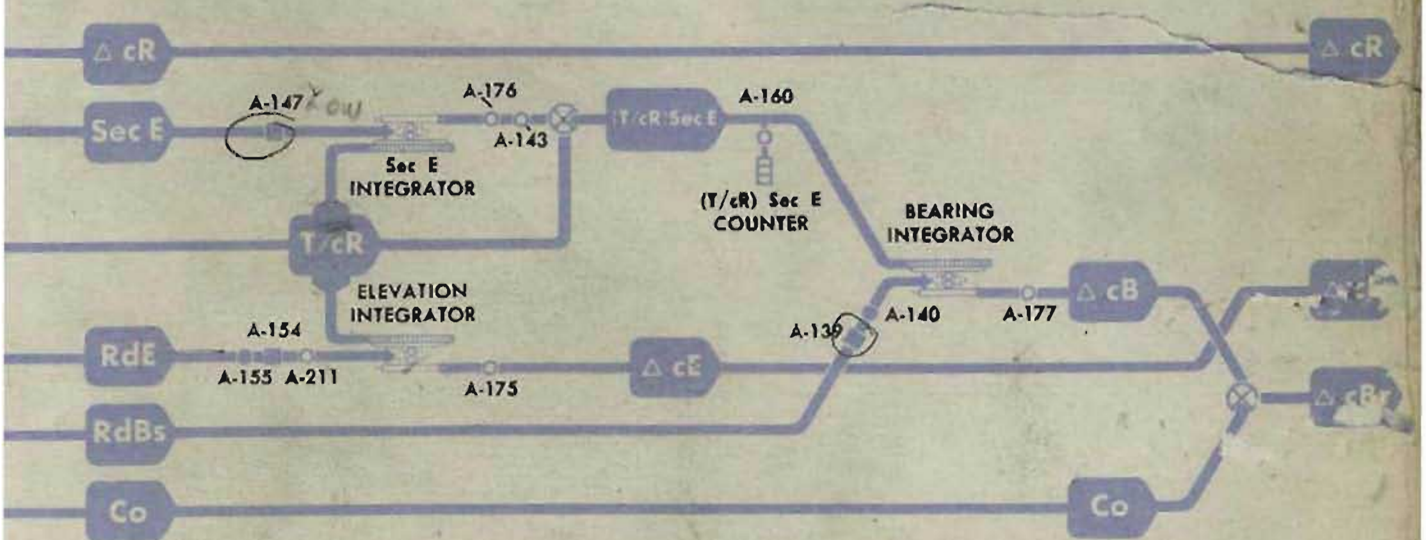
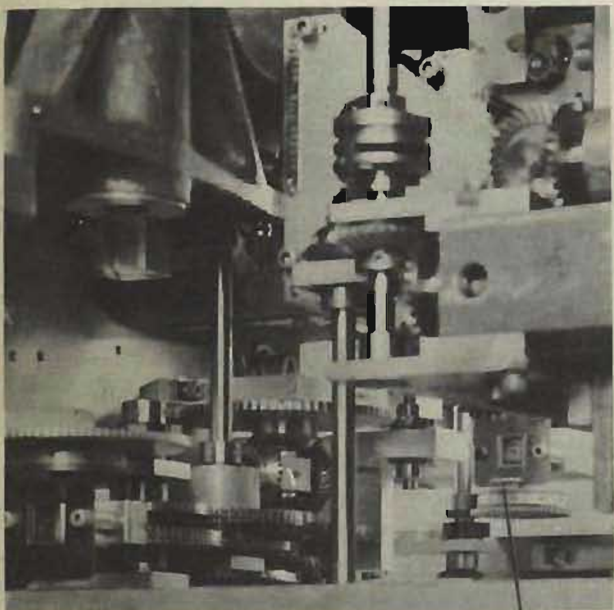
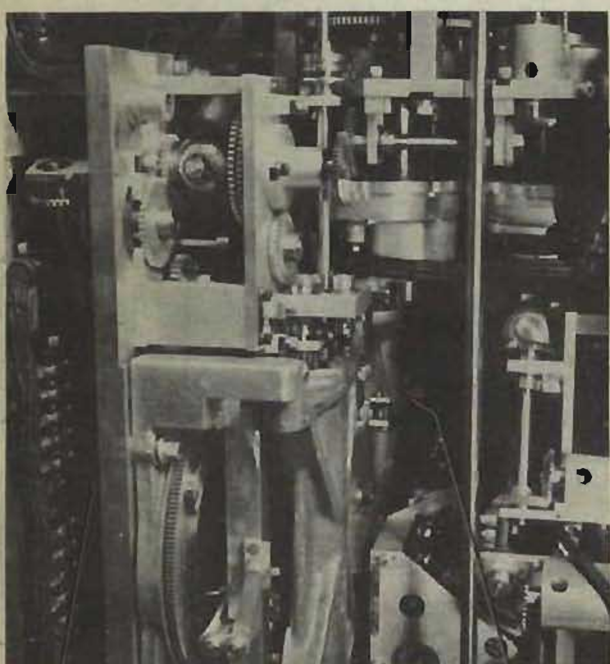


Table of Contents





Refining the adjustment of (T/cR) sec E

1 Set *E* at 0°.

2 Set *cR* at a low value.

3 Adjust A-147.

Loosen the locking screw. Adjust the vernier screw so that the *(T/cR)* sec *E* counter makes from 62.84 to 62.89 revolutions per 100 revolutions of the *T/cR* counter.

Turn the vernier screw counterclockwise to increase the number of revolutions.

Turn the vernier screw clockwise to decrease the number of revolutions.

Tighten the locking screw.

4 Set *E* at 70°.

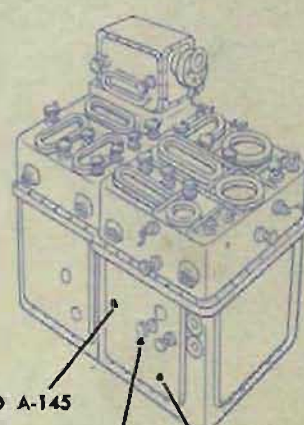
5 Adjust vernier A-145.

Loosen the locking screw. Adjust the vernier screw so that the *(T/cR)* sec *E* counter makes from 183.73 to 183.78 revolutions per 100 revolutions of the *T/cR* counter.

Turn the vernier screw counterclockwise to increase the number of revolutions.

Turn the vernier screw clockwise to decrease the number of revolutions.

Tighten the locking screw.



Refining the zero adjustment of RdE

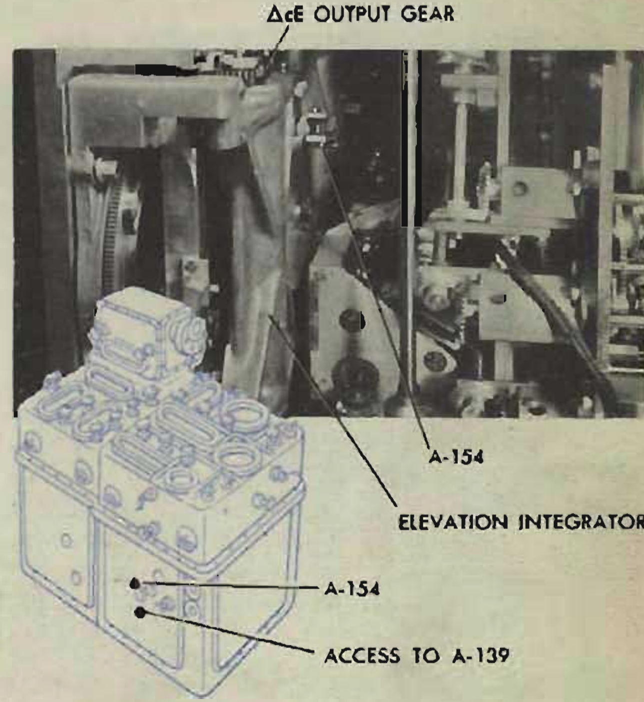
1 Set A and Br at 90°.

2 Set So, Sh, and dH at 0 knots.

3 Set E at 45°.

4 Set cR at 5000 — [redacted] yards.

5 Adjust A-154. When A-154 is correctly adjusted, there should be no ΔcE output from the elevation integrator.



Refining the 1/cR cam

1 Run problem 18, elevation B tests. Record the value of 360° − cE read at one minute.

2 Run problem 22, elevation B tests. Record the value of 360° − cE read at one minute.

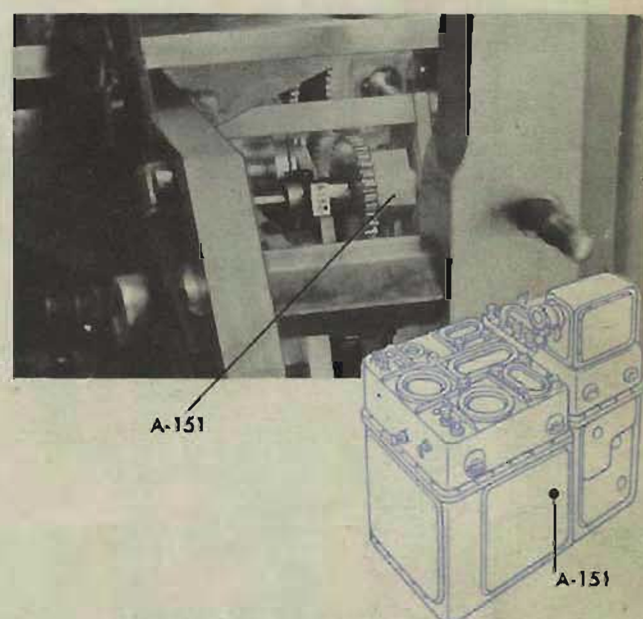
3 Compare the error in problem 22 to the error in problem 18.

4 Adjust A-151, until the error in problem 22 equals the error in problem 18 and has the same sign.

Turn the vernier screw counterclockwise to make problem 22 more minus, or clockwise to make it more plus. If a large adjustment is necessary, the result of problem 18 will also be affected.

5 Rerun both problems.

Repeat until the errors in problems 18 and 22 are equal and of like sign.



Refining the zero adjustment of RdBs

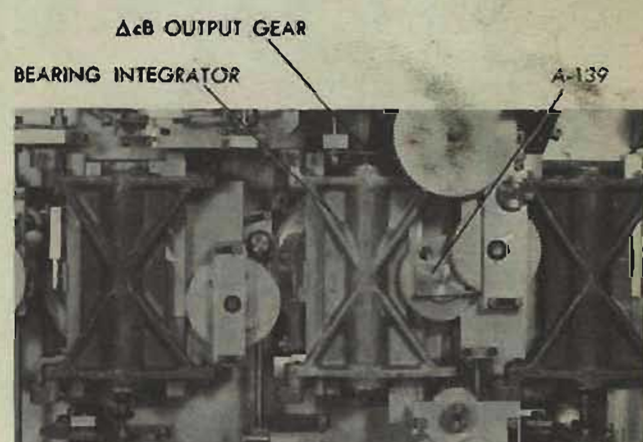
1 Set A and Br at 0°.

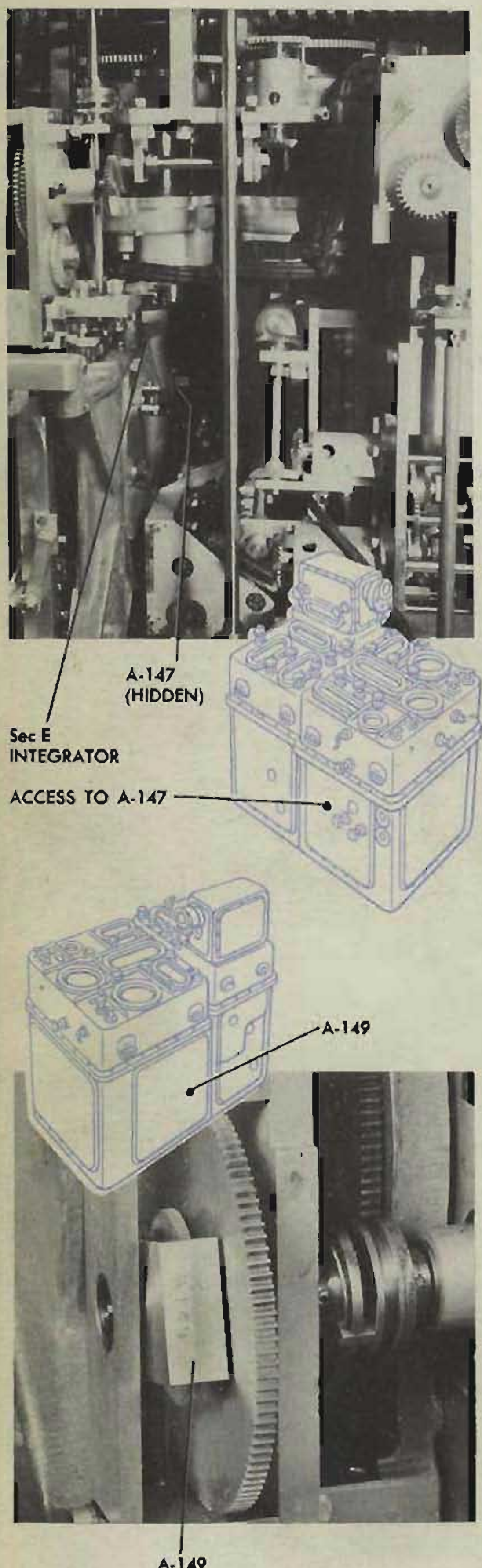
2 Set So and Sh at 0 knots.

3 Set E at 60°.

4 Set cR at 1600 yards.

5 Adjust A-139. When A-139 is correctly adjusted, there should be no ΔcB output from the bearing integrator.





Refining the sec E integrator

1 Run problem 25, bearing B tests, recording the value of 360° − *cBr* read at one minute. Compute the error.

2 Run problem 27, bearing B tests, recording the value of 360° − *cBr* read at one minute. Compute the error.

3 Compare the error in problem 25 to the error in problem 27.

4 Adjust A-147 until the error in problem 25 equals the error in problem 27 and has the same sign.
Turn the vernier screw counterclockwise to make problem 25 more plus, or clockwise to make it more minus.

Any adjusting will also change the results of problem 27.

5 Rerun both problems.

Repeat until the errors in problems 25 and 27 are equal and of like sign.

Refining the 1/cR integrator

1 ~~Adjust A-149 until the errors in problems 25 and 27 are between 0 and plus 10 minutes per minute.~~

~~Turn the vernier screw counterclockwise to make both errors more plus.~~

~~Turn the vernier screw clockwise to make both errors more minus.~~

Refining the sec E cam

1 Run problem 24, bearing B tests, recording the value of 360° − *cBr* read at one minute. Compute the error.

2 Run problem 33, bearing B tests, recording the value of 360° − *cBr* read at one minute. Compute the error.

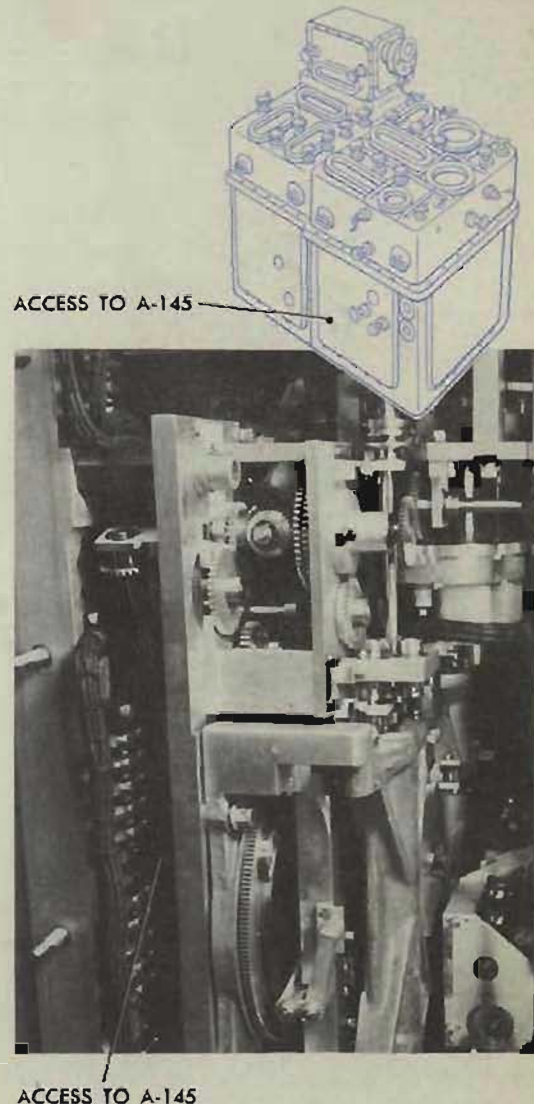
3 Compare the error in problem 24 to the error in problem 33. Adjust A-145 until both errors are at a minimum. This adjustment will change the results of both problems almost equally, but with opposite effect on signs.

Turning the vernier screw counterclockwise will make problem 24 more plus, and problem 33 more minus.

Turning the vernier screw clockwise will make problem 24 more minus, and problem 33 more plus.

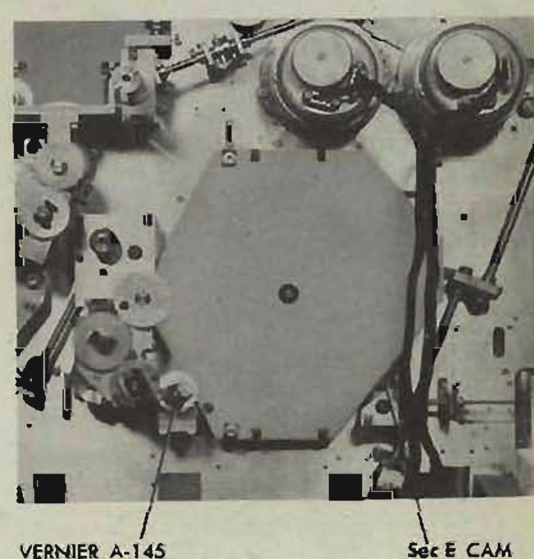
For example: If the error in problem 24 is plus and the error in problem 33 is minus, a clockwise adjustment will bring the errors in both problems to a minimum.

4 Rerun both problems after each adjustment until the results are satisfactory.



CHECKING THE REFINED ADJUSTMENTS

Run a complete set of elevation and bearing B tests. The errors should be within the allowable limits. If the errors exceed the allowable limits, readjust according to the types of error described earlier in this chapter. Check for mechanical defects.



C TEST ANALYSIS

C test analysis provides a means of locating and correcting C test errors. The analysis of C test errors is based on a complete set of C test and B test problem results. If A and B tests are satisfactory, C tests will usually be found satisfactory.

C tests check the adjustment and operation of both the relative motion group and the integrator group. B tests also give an accurate and thorough check of the integrator group. They differ from C tests since they are run with constant inputs, while C tests are run with constantly varying inputs.

CAUSES OF ERRORS IN C TESTS

At the point of manufacture, the C tests are run with a special setup to make the computer regenerative. Shipboard tests are usually run with the director to complete the regenerative system. The lost motion of the director receiver regulators, transmitters, and gearing all add to the lost motion of the computer receivers and mechanisms. For this reason, the allowable maximum errors that are listed on the C test record forms do not apply to C tests made on shipboard with the director.

Since the computer is made regenerative, the inputs of bearing, elevation, and range are controlled by their respective generated quantities. Thus an input quantity is directly affected by the accumulated error in the generated quantity. These errors in the input quantities will create errors in the rates, which in turn may cause a further increase in the errors in the generated quantities. The accumulation and regeneration of errors, therefore, is of great importance in C test analysis.

For example, in problem 10, if bearing is slow in the beginning, target angle and relative bearing will not decrease as rapidly as they should. This will create a negative error in dR which will cause range to decrease too rapidly. As the problem continues, range will accumulate an excessive negative error, which in turn may cause the $1/cR$ cam to overcorrect the previously slow generated bearing. This fast error in bearing accumulates and begins to decrease the error in range toward the end of the problem. Although the excessive error is in range, the step-by-step analysis of the problem shows that the original dR error was caused by a slow start in bearing. In order to correct this latter condition, the longer-range bearing B tests such as 27 would have to be made faster.

Transmission trouble

As long as the observed and generated dials remain matched, errors in the C tests are not being caused by transmission trouble. If the observed dial suddenly stops turning, or fails to remain matched to the generated dial, transmission checks should be made to locate the error.

Excessive lost motion

C tests may be in error even though the A and B test results were satisfactory. The A and B test errors may have been such that the addition of a little lost motion has caused excessive errors in C tests. It may be possible to make readjustments which will either reduce the B test errors or will change the sign of these errors, and thus reduce the C test errors.

Excessive lost output at the cross-over point

The cross-over point is the integrator position at which dR or RdE passes through zero and the output changes to the opposite direction. When the integrator is near the center position, the output torque is very low. If there is any overloading of the output line, the integrator will, in effect, have a wide zero output range instead of the theoretical "pin-point" zero position.

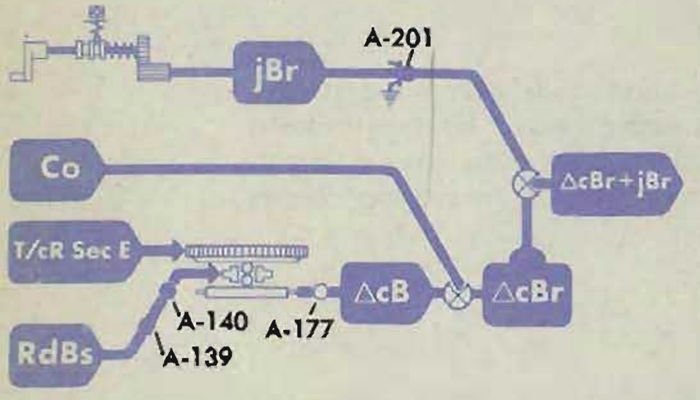
Problem 14 can be used to illustrate this condition. Elevation increases until bearing reaches 270°, and then decreases. If elevation increases at the correct rate until bearing reaches 270°, and then remains at the high value for several time intervals before decreasing, the elevation integrator may have failed to produce sufficient output at the cross-over point.

Loose frictions or faulty solenoid locks

The generated quantities may back out through a loose friction or a faulty solenoid lock.

To check the generated bearing or generated elevation friction, observe the respective crank while rerunning one of the C test problems which was in error. Any movement of the crank indicates a loose friction. To check range, the crank should be removed and both input gears observed. A friction should be tight enough to prevent the generated quantity from backing out through an input gear.

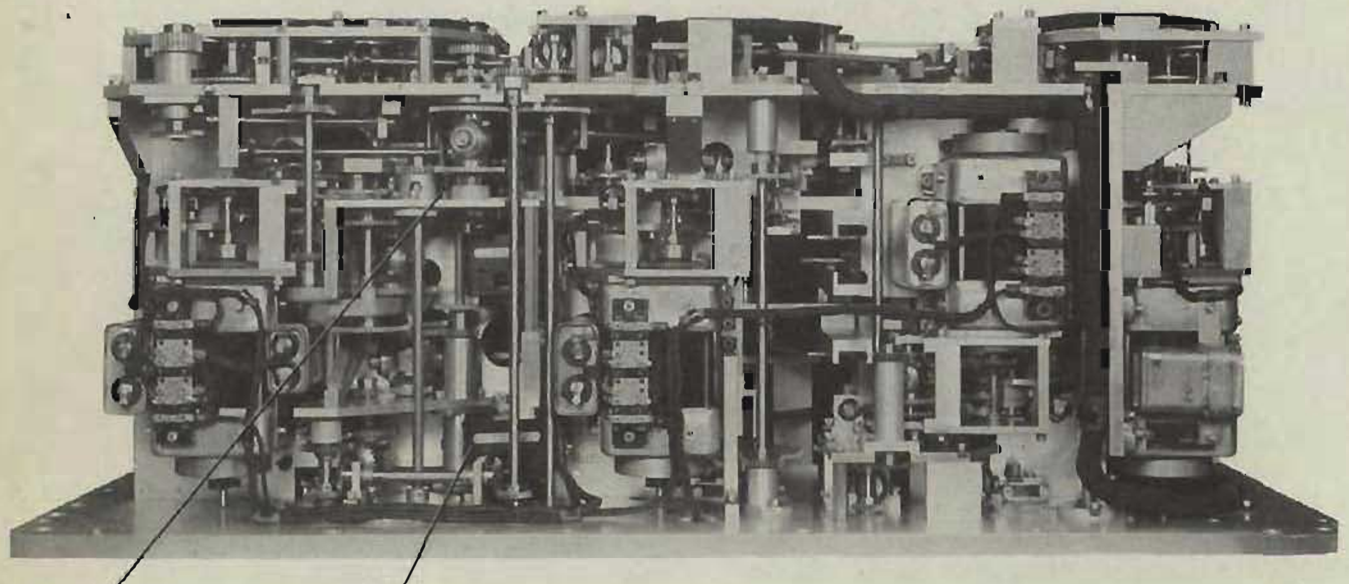
CAUSES OF BEARING ERRORS IN C TESTS



Excessive bearing errors in C tests may be caused by:

Error in generated bearing

If bearing B tests are satisfactory, bearing errors in C tests are not likely to be excessive. However, if bearing is in error but range and elevation are satisfactory, further analysis is necessary. If bearing is slow, with minus errors in increasing problems and plus errors in decreasing problems, generated bearing is probably *backing out*. This condition may be caused by a loose friction or a faulty solenoid lock. Check A-201 and the solenoid lock on the *jBr* line.



REAR OF CONTROL UNIT
COVER 1 REMOVED

It is possible for the errors in bearing B tests to be in such a direction that the addition of lost motion in the same direction causes excessive bearing errors in C tests.

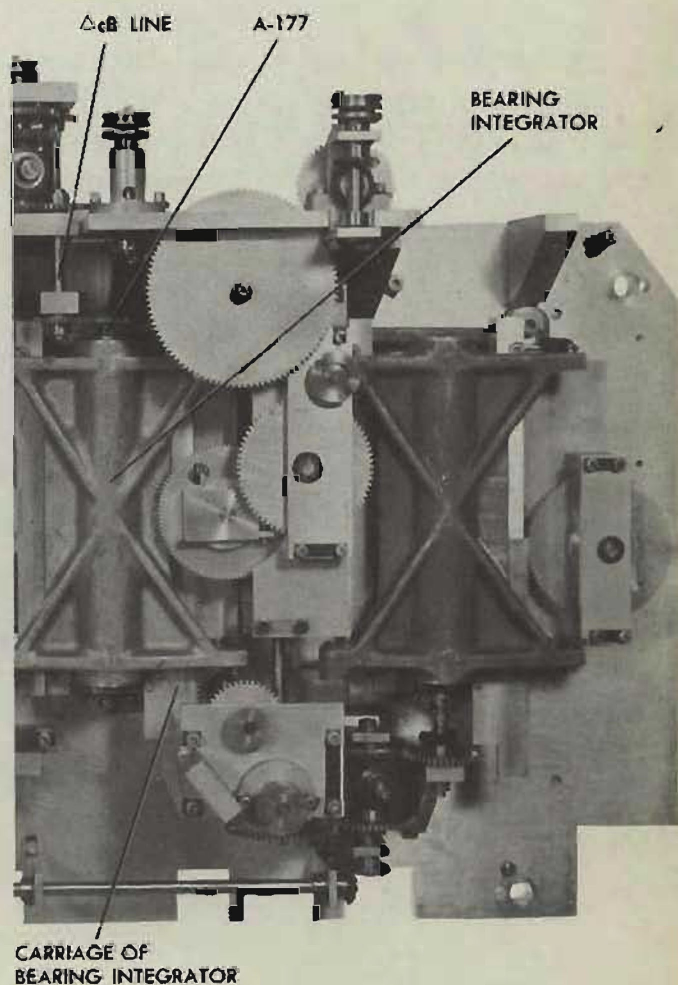
Refer to the errors in the bearing B tests. It may be possible to reduce the C test bearing errors by making readjustments either to reduce or to change the sign of the errors in those B test problems with setup conditions similar to the C tests.

(Note: It is recommended in B test analysis that problems 25 and 27 be given slightly plus errors to aid C tests.)

Before changing B test errors, determine the effect of such a change on the other generated quantities throughout C tests.

Accumulated range or elevation errors

Analyze the errors in range and elevation in B and C test problems. If all the range tests have a negative trend, it may be possible to improve bearing by making range more plus. This can be done by adjusting the range integrator so that the zero range rate B test problem has a slight positive error. It might also help if the errors in elevation B test problems are reduced or changed in sign. Determine what the effect will be on the other generated quantities throughout C tests.



INTEGRATOR GROUP REMOVED FROM COMPUTER

Error in target angle

If A test and bearing B test results are satisfactory, it can be assumed that *RdBs* is correct. To check this, run A test problem 6. Here an error of ½° in target angle results in an error greater than 13′ in *B′gr*. If the error in *B′gr* is excessive, see *A Test Analysis*, page 106.

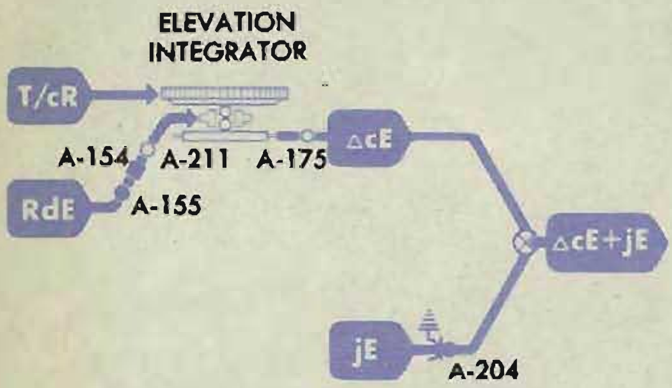
Bearing integrator

Check the bearing integrator for slipping or excessive lost output at the cross-over point. Inspect carefully for dirt or foreign material. Check the bearing integrator for overload. To do this, loosen A-177 and lift the gear out of mesh. Turn the △*cB* line and check that it is free and turns easily. Remesh the gear and tighten A-177.

RdBs shaft line

Check that the *RdBs* line is free. Lift the carriage of the bearing integrator until the lost motion of the line is taken up. Check that the carriage drops back down of its own weight. If it does not drop back, see *Shaft Lines*, OP 1140A.

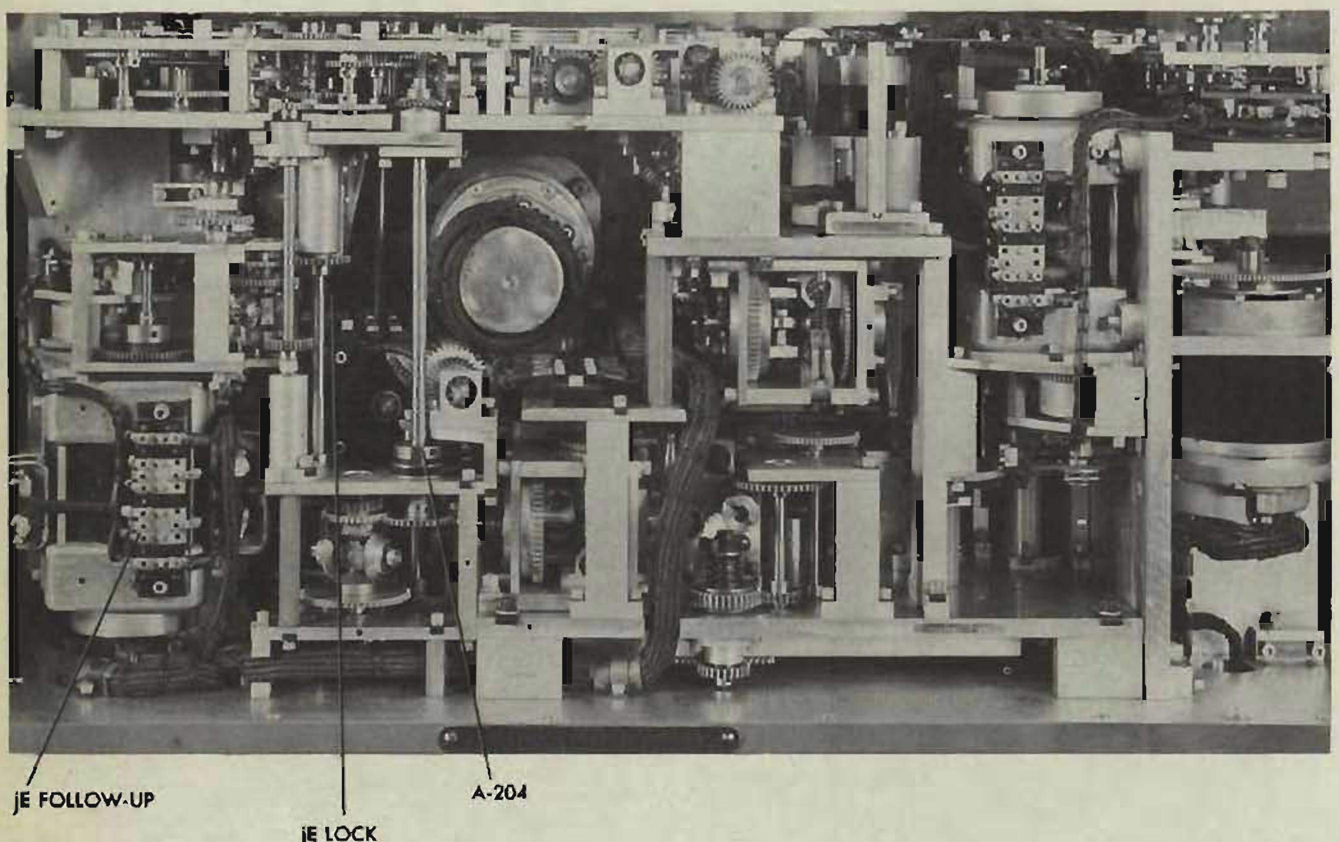
CAUSES OF ELEVATION ERRORS IN C TESTS



Excessive elevation errors in C tests may be caused by:

Errors in generated elevation

If elevation B tests are satisfactory, elevation errors in C tests are not likely to be excessive. However, if elevation in all problems is consistently slow, generated elevation may be backing out through a loose friction or a faulty solenoid lock on the *jE* line. Check A-204 and the solenoid lock on the *jE* line.



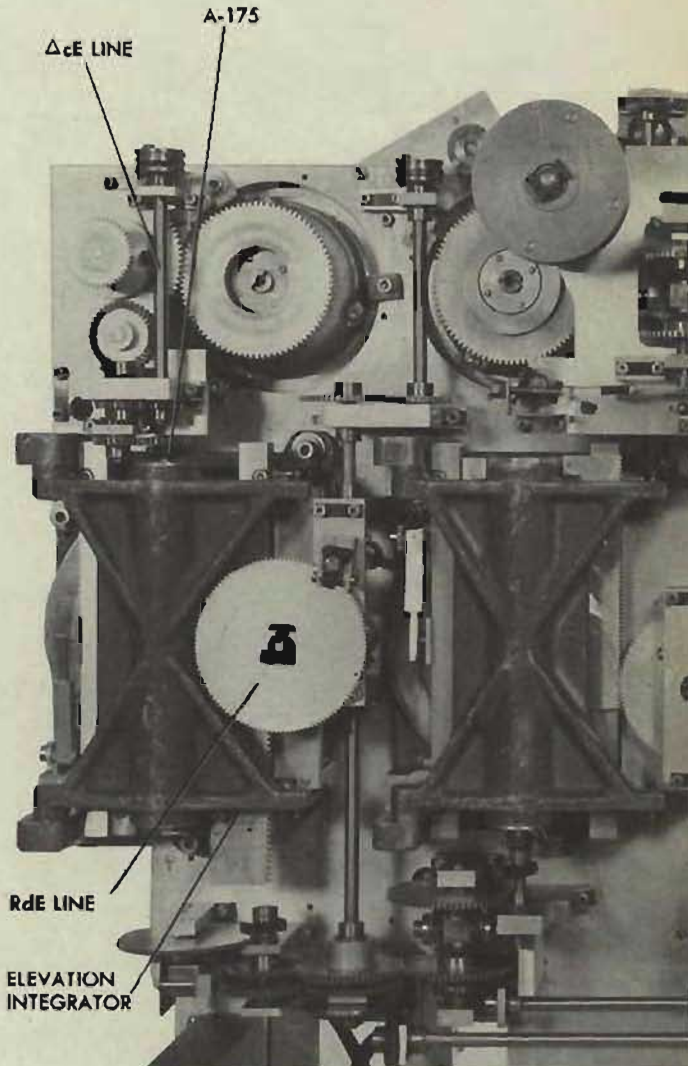
LEFT SIDE OF COMPUTER
COVER 1 REMOVED

It is possible for the errors in elevation B tests to be in such a direction that the addition of lost motion in the same direction causes excessive elevation errors in C tests.

Compare the elevation errors in C tests with the errors in elevation B tests. It may be possible to get more correct C test results by reducing the B test errors, or by changing their signs. However, before changing B test errors, determine whether the change will affect the other generated quantities throughout C tests.

Accumulated errors in bearing and range

Examine the errors in range and bearing in both B and C test problems. Determine whether the errors in range and bearing B tests can be reduced or changed in sign in order to reduce the C test elevation errors.



LEFT HALF OF INTEGRATOR GROUP

Error in RdE

If the errors in *Vs* in A tests are within the allowable limits, it can be assumed that *RdE* to the elevation integrator is correct. An error in *RdE* would also appear in B tests. If the errors in *Vs* are excessive, see *A Test Analysis*.

RdE shaft line

Check the *RdE* line for sticking or binding. Refer to *Shaft Lines*, OP 1140A.

Elevation integrator

Check the elevation integrator for excessive lost output at the cross-over point and for sticking or binding caused by dirt or foreign material.

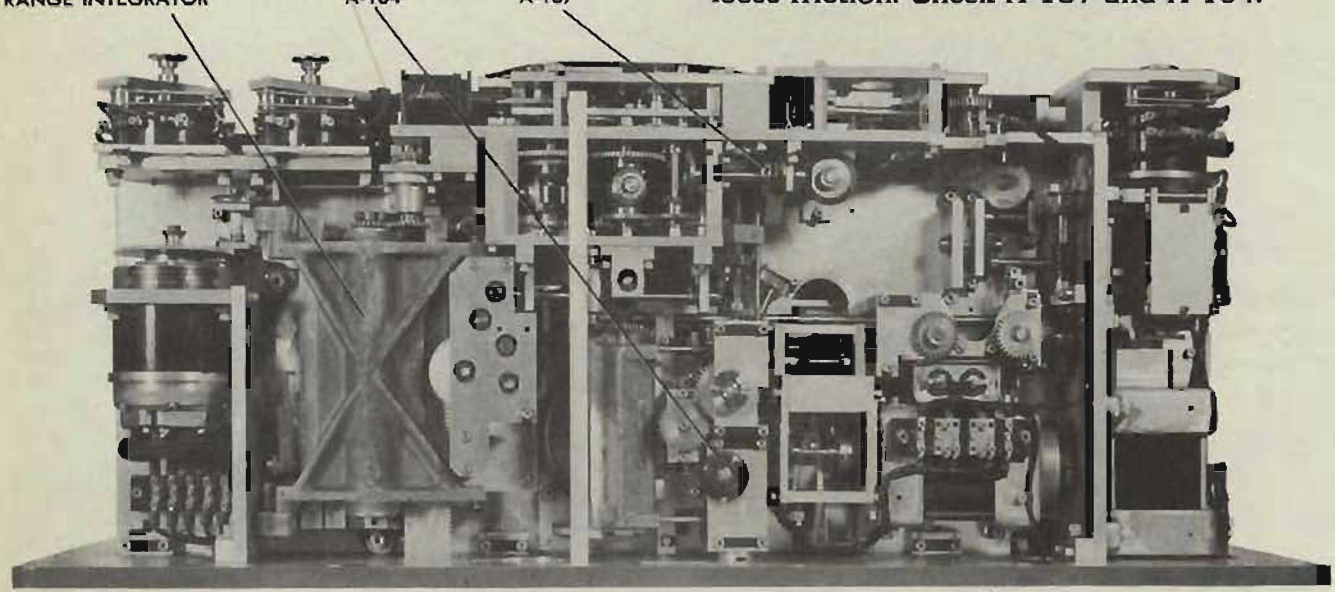
Check the integrator output for overload. To do this, loosen A-175 and lift the gear out of mesh. Turn the ΔcE line and check that it is free from sticks or binds. Remesh the gear and tighten A-175.

CAUSES OF RANGE ERRORS IN C TESTS

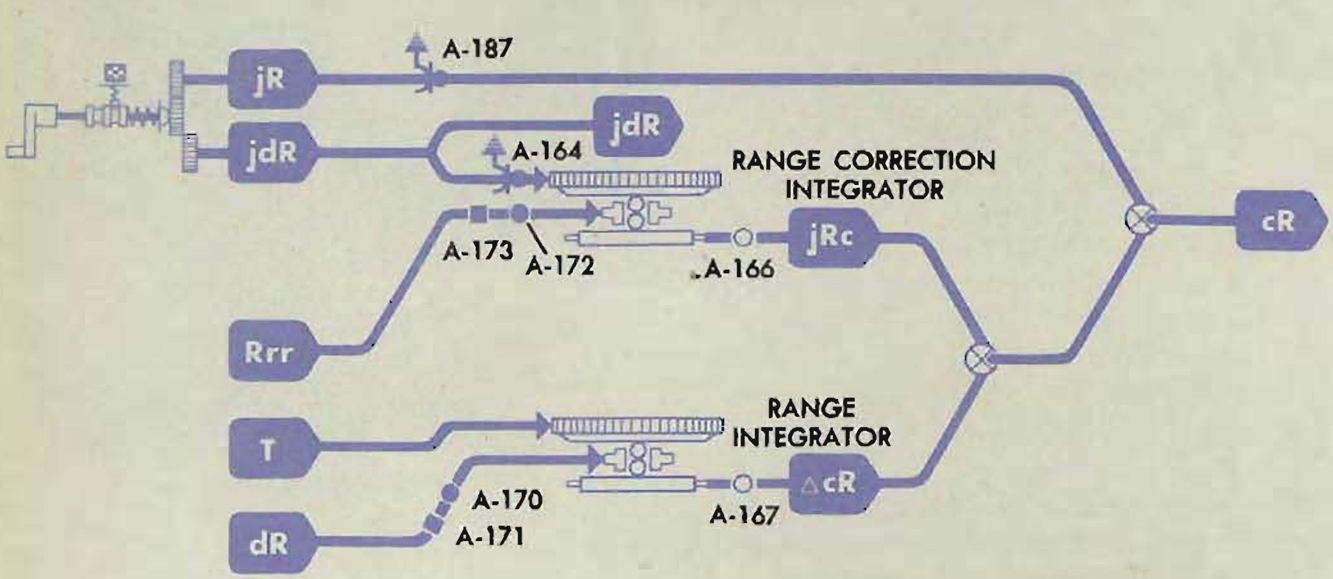
Excessive range errors in C tests may be caused by:

Error in generated range

If range is slow in all C test problems, generated range may be backing out through a loose friction. Check A-187 and A-164.



TOP FRONT OF COMPUTER



The errors in range B tests may be in such a direction that the addition of the over-all system lost motion may cause the C test range errors to become excessive. Analyze the errors in range B tests. It may be possible to improve the C test range readings by making corrections either to reduce or to change the signs of the errors in those B tests which have setup conditions similar to the C tests.

Error in dR

Check *dR* by running A test problems 1 and 9. If *dR* is in error, see *Checking the dR Network*, page 134.

Accumulated error in bearing and elevation

Any error in bearing means an equal error in target angle, which, at high target speeds, results in a large error in *dR*. A range rate error caused in this way must be corrected by correcting the bearing error. This usually means that adjustments should be changed in such a way as to make errors in bearing B test problems 25 and 27 more positive.

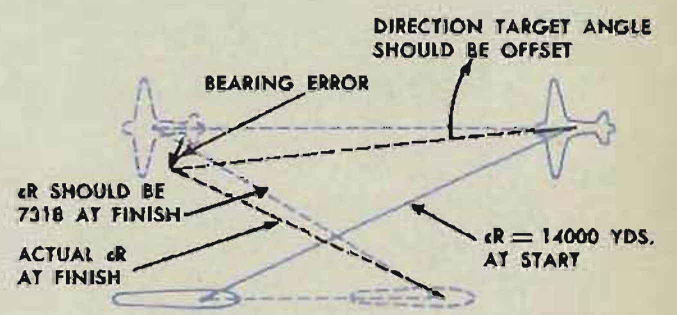
Analyze the elevation errors in B and C tests. Determine whether the B test errors can be altered or changed in sign in a way which will improve the C test range readings.

Error in target angle

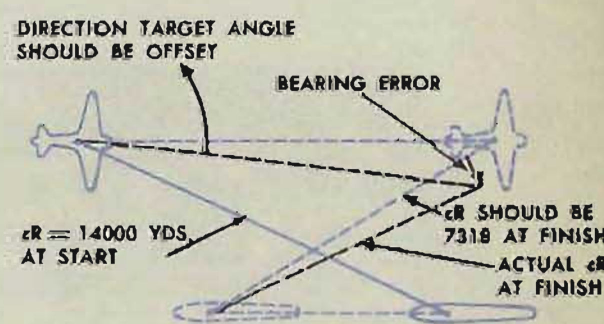
An error in target angle too slight to affect A test results may nevertheless cause excessive C test range errors. In order to determine and correct such an error in target angle, the following procedure is recommended:

1. Using the problem results, make an overlay of the diagrams for problems 8 and 9. Draw lines to indicate range and bearing at the end of each problem. Problems 8 and 9 are used because they have numerically equal rates. Therefore, when target angle is accurately adjusted, the two problems should have nearly equal range errors. When the range errors in the two problems differ greatly, a correction to target angle is indicated.
2. Repeat the problem with the larger range error, offsetting *A* very small amounts up to about half the width of a graduation mark. The offset should be in the direction which will improve the range readings in this problem.
3. When an offset is determined which satisfactorily improves range in the selected problem, rerun the other problem, using the same offset. The correct amount of offset will be indicated when the range errors in the two problems are about equal and of like sign.

TYPICAL PROBLEM OVERLAYS



PROBLEM 8



PROBLEM 9

4 Using the selected offset, rerun the remaining problems to make sure that none will be seriously affected.

5 Run A test problems 1 and 10, setting up target angle with the selected offset. Compare the results with previously run A tests, and check that there is no marked difference in the readings.

6 Remove the window over the target and ship dial group.

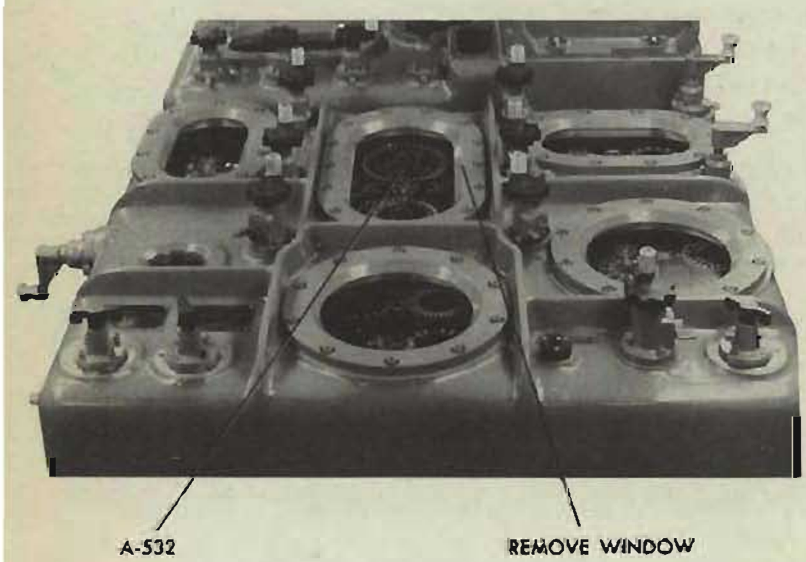
7 Set up C test problem 8 with the selected trial offset in target angle.

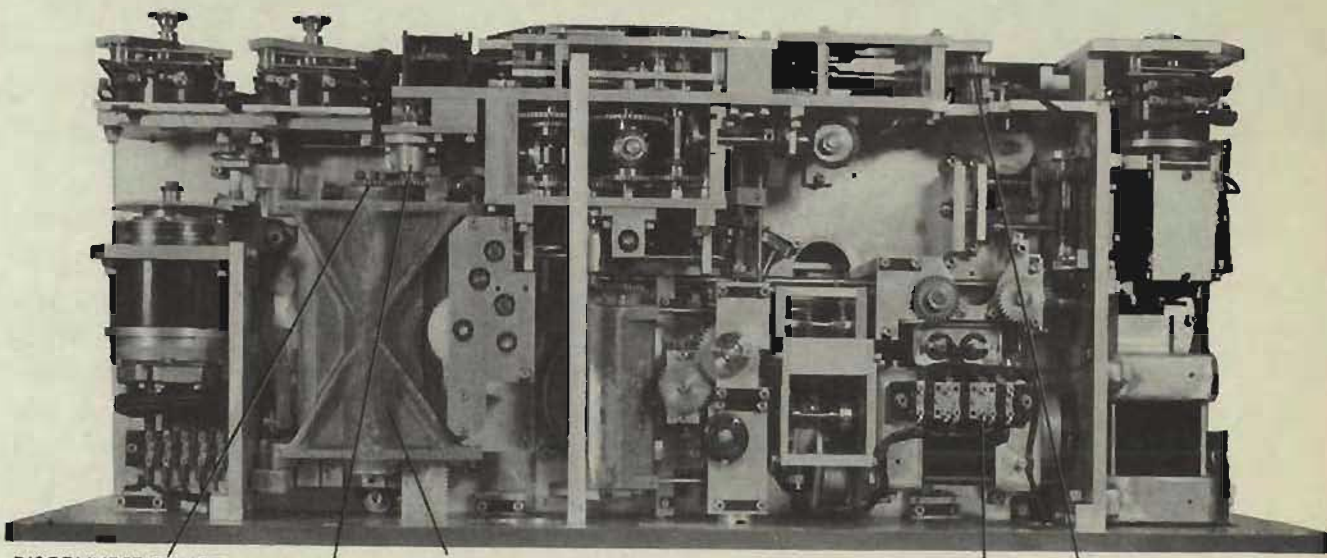
8 Loosen the dial screws (A-532) and slip the dial to read exactly 330°.

9 Tighten A-532.

10 Rerun problems 8 and 9.

11 RERUN ALL A, B, AND C TESTS.





FRONT OF COMPUTER—COVER REMOVED

Sticking or binding

Sticking or binding in a shaft line or unit may be causing an error in *dR* during the C test. The following test may be used to determine whether the computing mechanism is being affected by this type of casualty. With power on, set target angle at zero. Carefully set target speed at exactly 200 knots, bringing it on slowly in the increasing direction. Mark a tooth on the friction drive gear which meshes with the *dR* motor pinion, and opposite this make an index mark on the plate. Now run *Sh* up to about 210 knots and slowly bring it back to exactly 200 knots. The spread or lag in *dR* can now be measured by counting the number of teeth between the index and the marked tooth. If the spread is considerably more than four teeth, the trouble must be eliminated. Check the shaft lines and units involved in the computation of *dR*, working back from the *dR* follow-up and its input gearing. See *Shaft Lines*, OP 1140A.

In order to include the *Ct* and *A* shaft lines in the above check, repeat the test with *Sh* fixed at 200 knots while setting *A* at 90°, first in the increasing direction and then in the decreasing. The spread in *dR* may be measured on the same gear.

Check the range integrator for overload. To do this, disconnect the integrator and check the ΔcR line. Reconnect the range integrator.

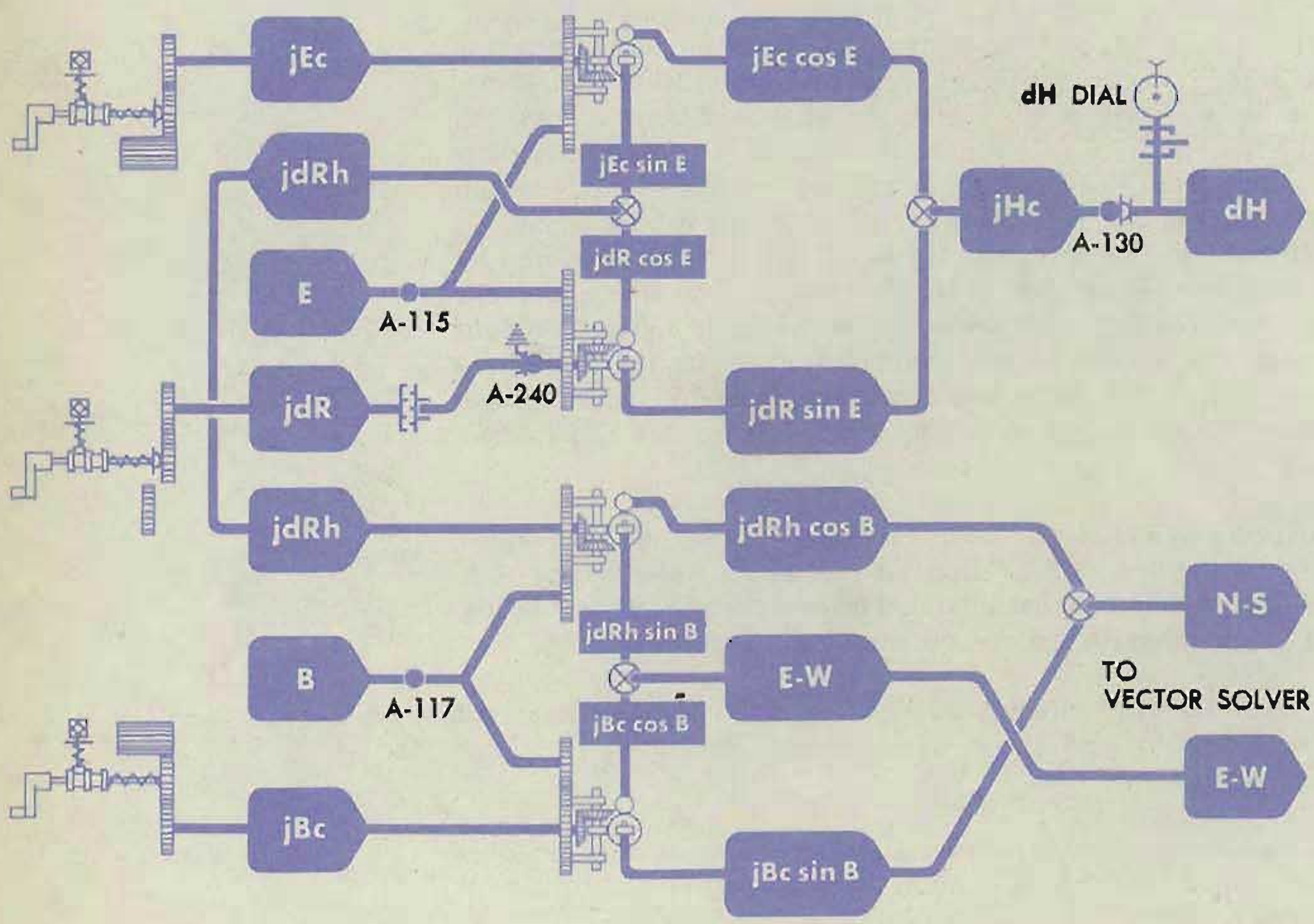
Check the integrator for excessive lost output at the cross-over point, and for sticking, binding, or jamming caused by dirt or foreign matter.

RATE CONTROL TEST ANALYSIS

This test analysis provides information for locating and correcting rate control test errors.

An error of ±5 knots is the maximum allowable error for the acceptance test. However, if the computer has been operating satisfactorily with rate control errors slightly higher than the allowable, it is not advisable to attempt a readjustment as the errors affect only the solution time of the tracking problem and not the actual gun orders.

Before attempting to analyze and correct rate control errors, it must first be determined that the specified inputs were not introduced too rapidly. The *Sh* and *Ct* follow-ups are the limited type which drive more slowly than other types. Hence, if the rate corrections are introduced faster than the follow-ups can handle them, a portion will be lost in slippage at the vector solver input frictions. If the follow-up contacts and limit buffers are in correct adjustment (see page 561), they will not cause test errors when the inputs are introduced smoothly and at the proper speed.



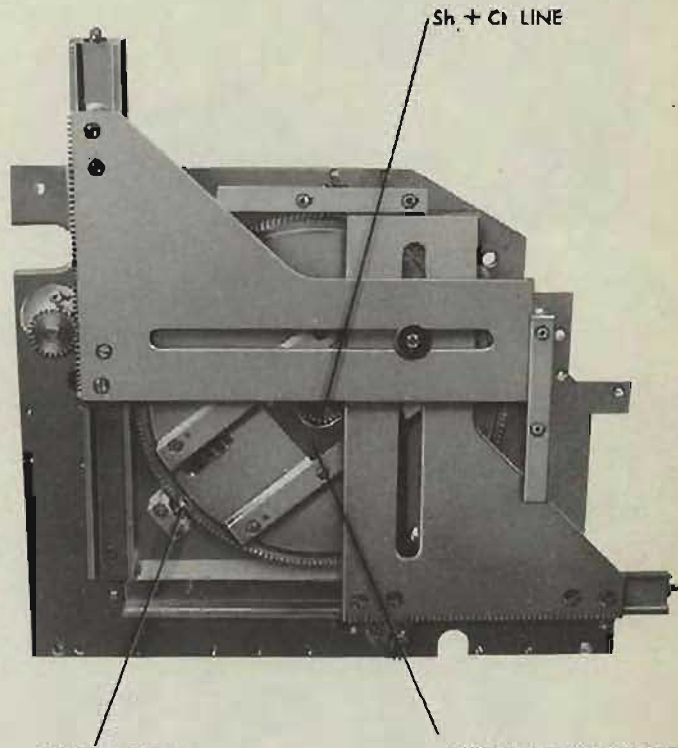
LOCATING AND CORRECTING ERRORS

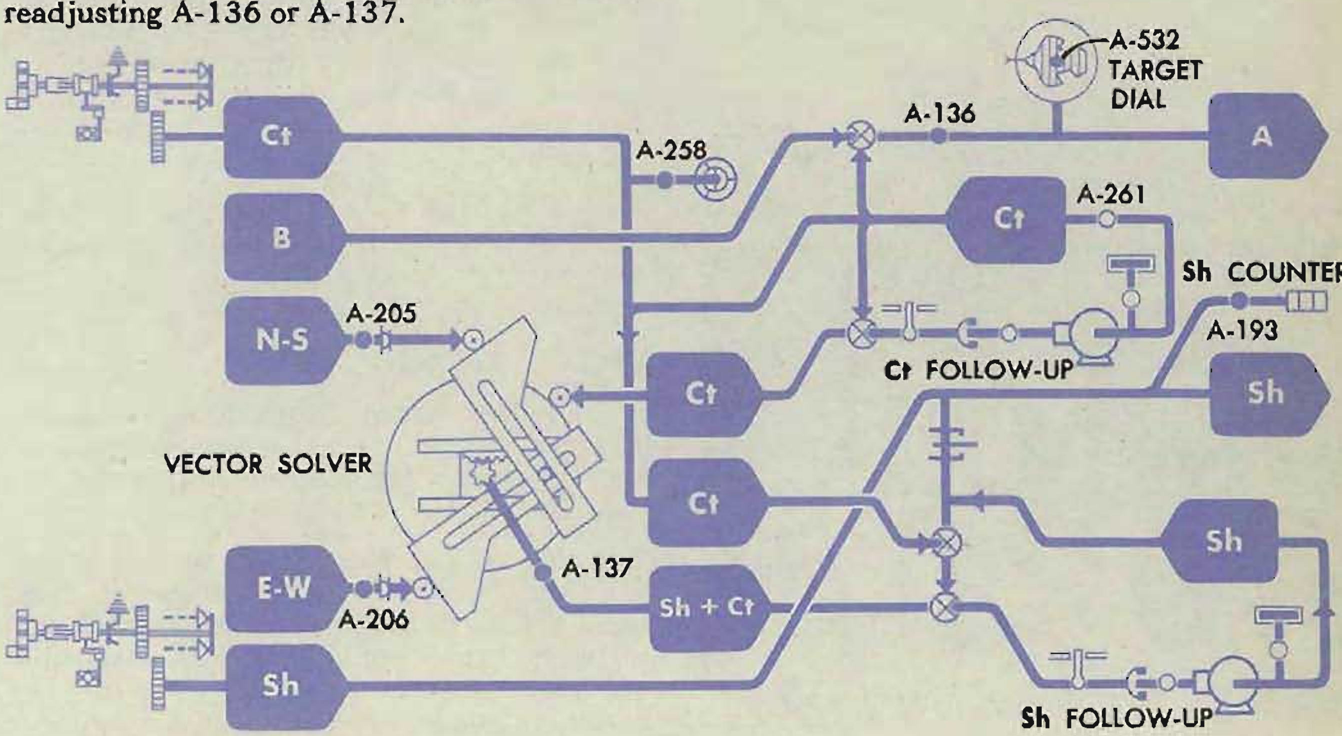
Failure of Ct or Sh to rate control

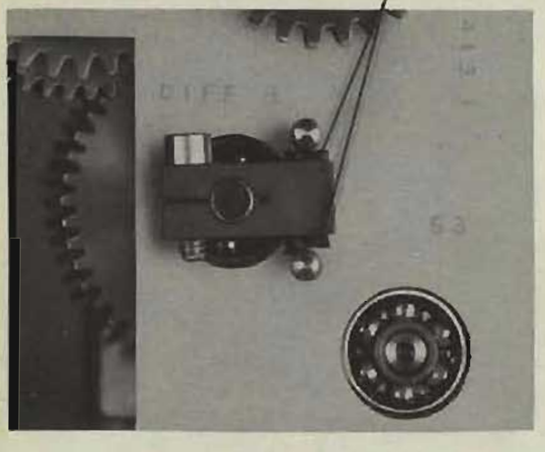
If both *Ct* and *Sh* fail to respond, the power supply to the motors should first be checked. This check involves the two handcrank switches. If either one is open or defective, the power to both motors will be out.

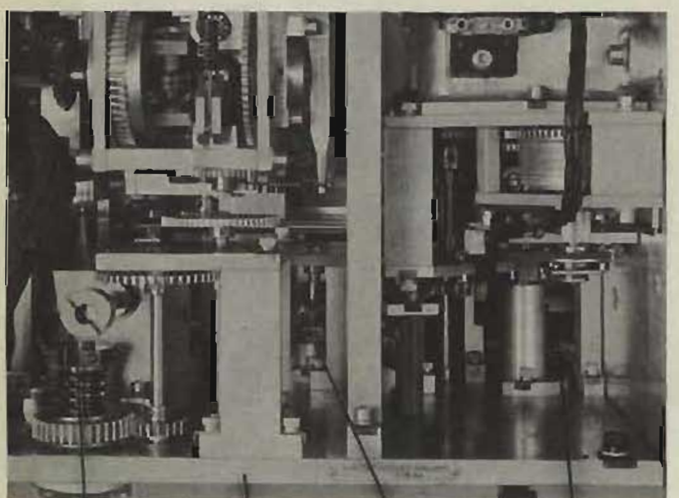
Check the follow-up control contacts. See page 561.

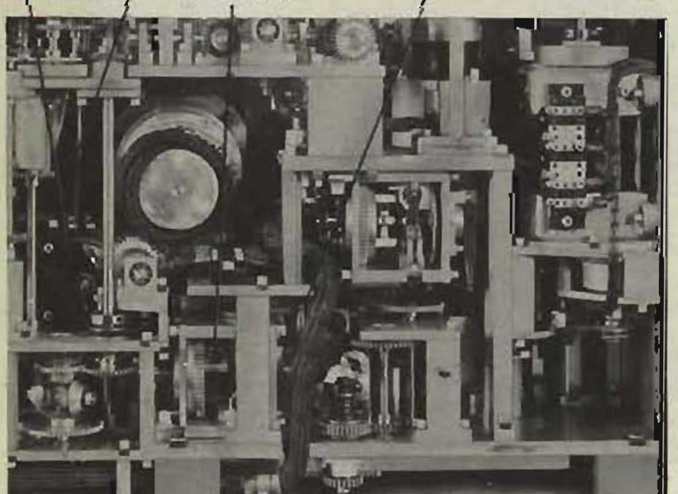
If *Ct* and *Sh* fail to change, the vector solver may be jammed or damaged as a result of faulty readjustment technique. Such damage can be caused by hand-driving *Sh* into either limit while A-137 is upset or only approximately positioned. With A-137 out of adjustment, it is possible to drive the vector-solver pin carriage beyond the end of its guide rails. When this happens, the carriage may hit one of the rack rails or one of the four vector-gear rollers, thereby damaging the *Sh* + *Ct* line. If the carriage should *extend* into the spaces between two of these obstructions, it would lock the *Ct* line. When one of these restrictions is encountered, the inertia of the motor on the line being turned will usually cause damage before the restriction is felt. For this reason, extreme care must be taken when readjusting A-136 or A-137.











Errors in Ct or Sh

If the changes in *Sh* are too small, or if *Ct* does not change as much as specified in the special test for changes in *Ct* given on page 57. the errors may be due to faulty spacing of the follow-up contacts or of the limit buffers. When the contacts do not "make" sufficiently to maintain proper motor speed in each direction, the frictions on the N-S and E-W lines will slip, causing some loss of output. In this case the outer contacts may be too far apart, the center contact may be off center, causing a loss in one direction, or the neoprene buffers on the limit arm may be too thick, causing excessive restriction of contact motion. For readjustment of the follow-up contacts and limit buffers, see Locating Casualties, *Ct* and *Sh* follow-ups, page 561.

Check the vector solver frictions, A-205 and A-206.

Errors in the amount that *Ct* changes may also be due to faulty adjustment of the vector-solver speed pin. Check A-137.

If *Sh* changes when only *Ct* should change and the *Ct* change is too small, or if *Ct* changes when only *Sh* should change and the *Sh* change is too small, check A-117 and A-136. (When a change in *A* is called for, other quantities will begin to change after *A* has moved away from its initial position. At 80° *E*, it is normal for quantities other than the one being checked to change slightly.)

When the changes resulting from a smooth input are too small and appear to be rough or intermittent, check the component integrators for slippage due to dirt or wear. Also check the associated shaft lines. See OP 1140A.

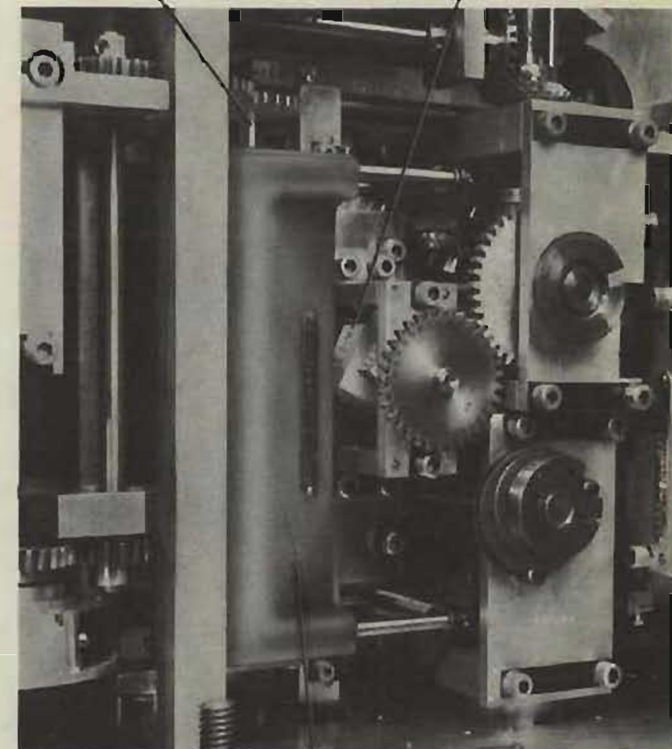
With *E* at 0°, if *Ct* and *Sh* change too little when *cR* is changed, and *dH* also changes by some amount, check A-115.

Errors in dH

If *dH* fails to change, or changes erratically or intermittently, check the elevation component integrator for slippage due to dirt or wear. Refer to OP 1140A.

When *Ct* and *Sh* changes are correct, but *dH* is erratic or intermittent, check the *jHc* friction, A-130. If the friction is correctly adjusted and the trouble still exists, check the *dH* gearing and component solver for sticking and jamming. Refer to OP 1140A.

At 0° elevation, an error in the adjustment of *E* to the elevation component integrator, A-115, may be indicated by either of two symptoms: (1) An elevation correction causes *dH* to change insufficiently and *Sh* and *Ct* to change when they should not; or, (2) a range correction causes a change in *dH* when only *Sh* or *Ct* should change.



Errors when range corrections are made

If the specified changes are incorrect throughout the test when *cR* is increased or decreased 450 yards:

Check the elevation component integrator for slippage due to dirt or wear.
Check the carriage adjustment of the range correction integrator, A-173.

When increasing or decreasing *cR* causes no change in any of the quantities, check the *jdR* clutch. See OP 1140A.

Interchange or reversal of specified outputs

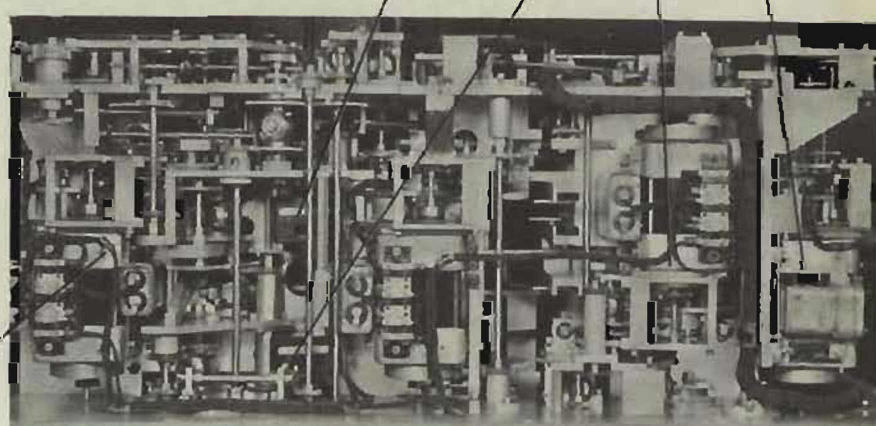
If, after readjustment to any of the rate control units, there is an interchange of test results, the vector solver or one of the component integrators is probably 90° out.

If the test results are reversed in direction, they indicate that one of the units is 180° out.

Errors in AUTO rate control tests

If the SEMI-AUTO rate control tests are satisfactory but errors exist during the AUTO rate control tests:

Check the operation of the solenoid locks and clutches. See page 553.
Check the operation of the *jE* and *jBr* follow-ups. See page 559.



TRANSMISSION TEST ANALYSIS

LOCATING THE CAUSE OF ERRORS

The causes of errors in transmission tests may be divided into three groups:

Receiver trouble
Reversed wiring
Open or shorted wiring

RECEIVER CHECK

Check the receivers as the first step in locating transmission test errors. Transmit a continuous signal and check the receiver output for one or more of the following symptoms:

No response

If the output does not turn or the synchro rotors do not follow the signal, make sure that the circuit is completely energized. Check all fuses. Check that the servo motor or capacitor is not dead. Check the synchro rotors for torque if they are accessible. Refer to *Synchro Receivers*, OP 1140A.

Erratic response

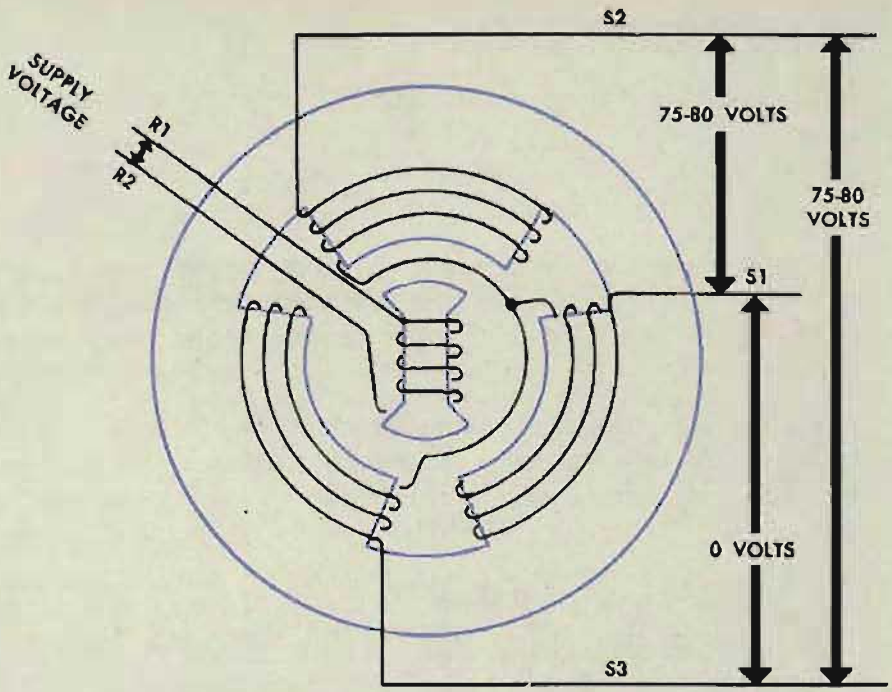
The receiver may jiggle, hunt, or follow in only one direction or its output may be rough or sluggish. See *Synchro Receivers*, OP 1140A.

Runaway response or drift

The servo runs constantly or drifts off from a synchronization point. This may be caused by open or shorted wiring, or mechanical defects. Refer to *Synchro Receivers*, OP 1140A.

Slow synchronization

If a receiver synchronizes too slowly, the cause may be a tight friction, an overloaded output line. or dirty contacts. Refer to *Shaft Lines*, and *Synchro Receivers*, OP 1140A.



VOLTAGE CHECK

A voltage check should be made to make sure that the stator windings are not being subjected to excessively high voltages. This check is especially important on new installations and on units where the wiring has been replaced. The voltage check is made at the computer terminal blocks. Refer to the wiring diagram for the unit being checked. To make the voltage check, transmit a zero signal and check the following voltages with all wires connected. (Note: A zero signal is one with the transmitter on electrical zero and not necessarily with the dial on zero. For example, electrical zero for range is 10,000 yards.)

R1-R2 should equal the power supply voltage, normally 115 volts.

S1 — S2 should be between 75 and 80 volts.

S2 — S3 should be between 75 and 80 volts.

S1 — S3 should be zero volts.

There should be no voltage between the rotor and the stator connections, except for an initial flicker. Note: Auto transformer type transmitters will show voltage between the rotor and the stator connections.

If the voltage across R1 and R2 is low, and a voltage equal to the power supply voltage exists between a rotor lead and a stator lead, they have been interchanged. De-energize the circuit and check the wiring to locate the interchanged leads. Refer to *Wiring*, OP 1140A.

If the voltage across R1 and R2 is equal to the power supply voltage and yet there is voltage between the rotor and the stator connections, it indicates a short in the wiring. De-energize the circuit and check the wiring to locate the short. Refer to *Wiring*, OP 1140A.

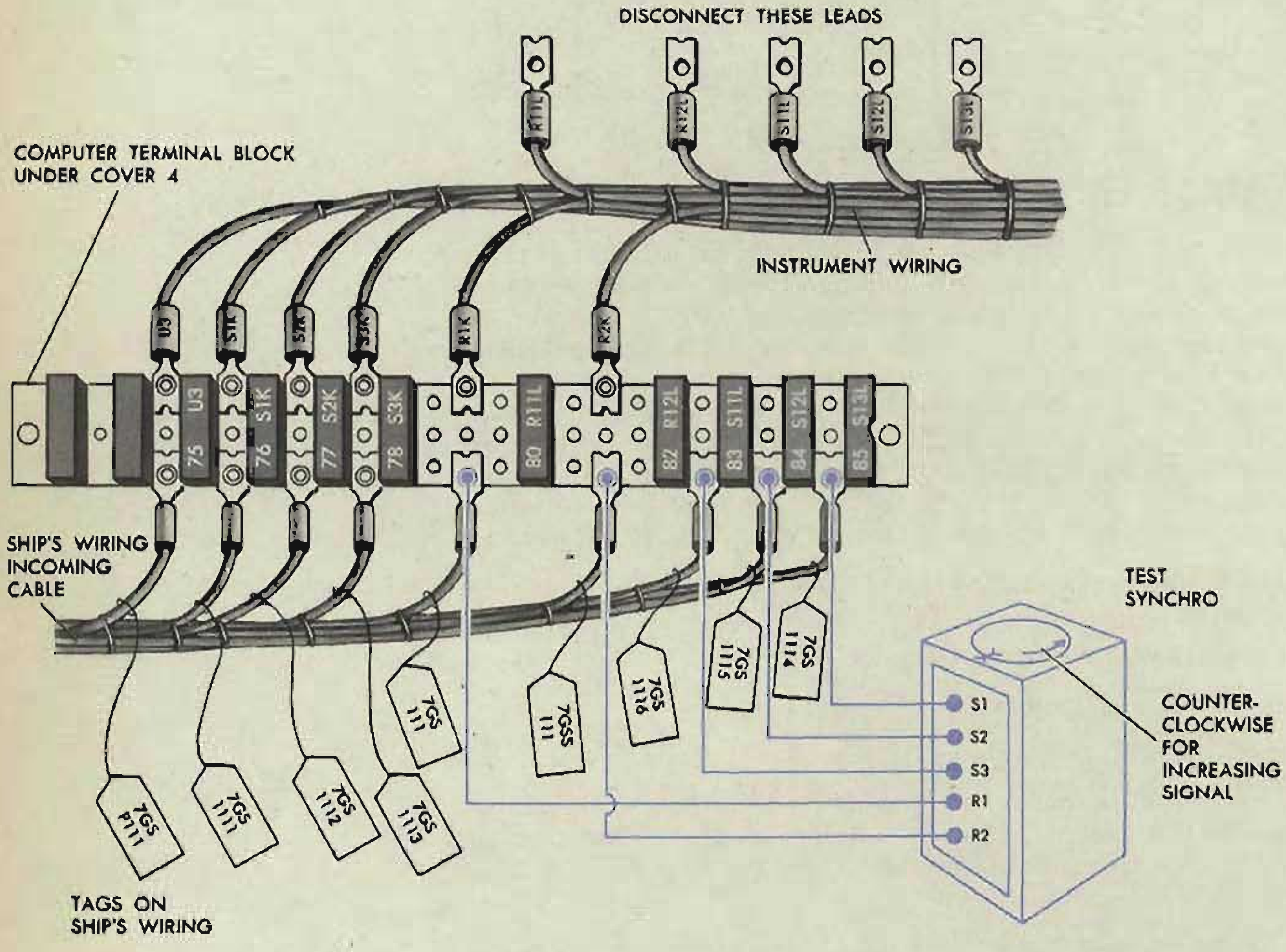
TEST SYNCHRO CHECK

A test synchro (standard motor) can be used to locate the error.

Using a test synchro to check a receiver

Disconnect the receiver leads at the computer terminal block to remove any possibility of feedback. Connect the test synchro to the ship's wiring at the proper terminals and energize the circuit.

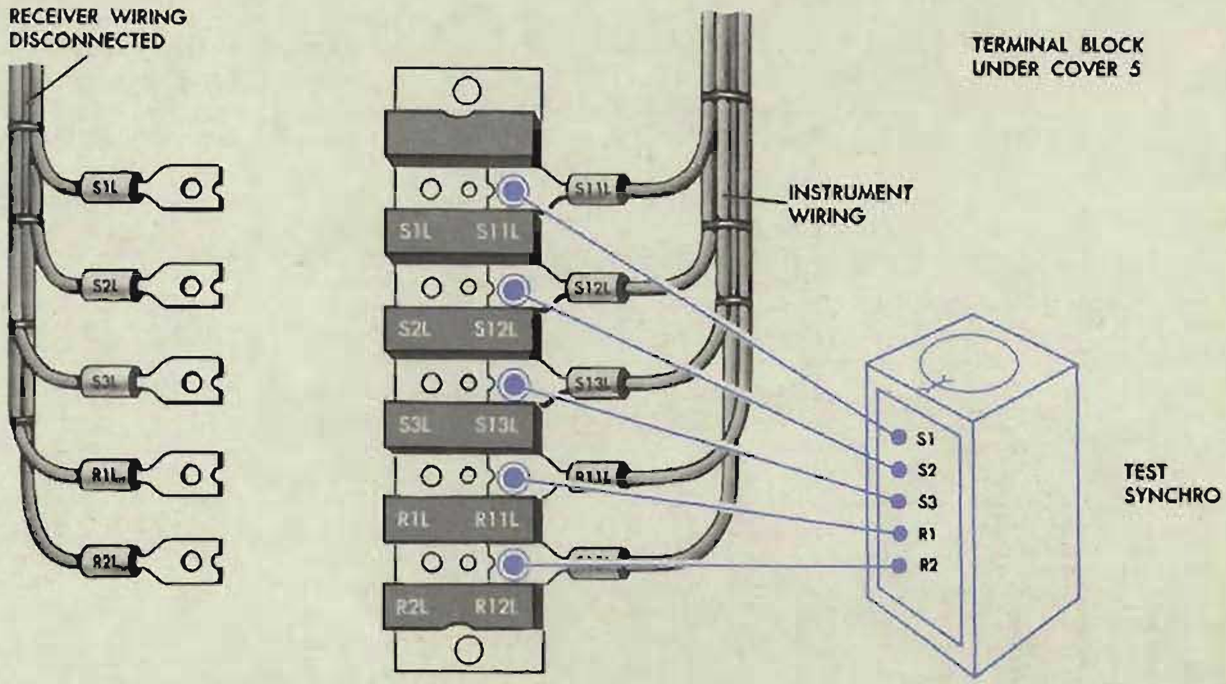
The illustration shows the fine synchro leads of the ship course receiver disconnected from the terminal block. The test synchro leads are connected to ship's wiring.



If the test synchro shows that the value being transmitted to the computer is in error, the trouble is not located in the computer. Refer to OP 1303.

If the test synchro shows that the value being transmitted to the computer is correct, but the receiver output is faulty, reconnect the receiver leads and move the test synchro to the receiver terminal block.

With the test synchro connected to the receiver terminal block of the fine synchro of the *Co* receiver, the lead connections would be as shown.



The test synchro now indicates whether the trouble is in the instrument wiring or the receiver. Refer to *Wiring*, and *Synchro Receivers*, OP 1140A.

Using a test synchro to check a transmitter

Disconnect the ship's wiring to the transmitter stator leads at the computer terminal block. Connect the standard test synchro to the instrument wiring at the proper terminals and energize the circuit.

If the test synchro shows that the value being transmitted from the computer is correct, the trouble is not in the computer. Refer to OP 1303.

If the test synchro shows that the value being transmitted from the computer is incorrect, reconnect ship's wiring to the transmitter stator leads and move the test synchro to the transmitter terminal block. The test synchro now indicates whether the trouble is in the instrument wiring or in the transmitter. Refer to *Wiring*, and *Synchro Transmitters*, OP 1140A.

TRANSMISSION TEST ANALYSIS TABLE

The following table will help to locate the cause of error. The transmitted value is electrical zero and the test synchro is the receiver.

Received Value	Direction of Rotation	Torque	Cause
300°	Reversed	Strong	S2 and S3 reversed, and R1 and R2 reversed
300°	Correct	Strong	R1 and R2 reversed, S3 to S1, S1 to S2 and S2 to S3
240°	Correct	Strong	S1 to S3, S2 to S1, S3 to S2
240°	Reversed	Strong	Reversed S1 and S2
180°	Correct	Strong	Reversed R1 and R2
180°	Reversed	Strong	S1 and S3 reversed, and R1 and R2 reversed
120°	Correct	Strong	S1 to S2, S2 to S3, S3 to S1
120°	Reversed	Strong	Reversed S2 and S3
90° or 270°	Correct	Strong	Shorted Rotor
60°	Correct	Strong	R1 and R2 reversed, S1 to S3, S2 to S1, S3 to S2
60°	Reversed	Strong	S1 and S2 reversed, and R1 and R2 reversed
0° or 180°	Correct	Weak	Open Rotor
0° or 180°	Correct at 0° Reversed at 180°	Weak	Open S2
0°	Reversed	Strong	Reversed S1 and S3
Dead Space 300° to 0°	Erratic	Weak	Open S1
Dead Space 0° to 60°	Erratic	Weak	Open S3
Locked on 120° or 300°			Shorted S1 and S2
Locked on 60° or 240°			Shorted S2 and S3
Locked on 0° or 180°			Shorted S1 and S3

The table is designed for a synchro calibrated at 360° per revolution and must be converted for a synchro with a different calibration. For example, on most destroyer installations, the value of the *So* receiver synchro is 40 knots per revolution. If the receiver synchronizes at 20 knots instead of 0 knots, refer to the table for "received value—180°." If there is a dead space between zero and 7 knots, refer to the table for "dead space—0° to 60°," etc. On a receiver such as the *Rj* receiver which has a value of 4000 yards per revolution, the limit stop which functions at OUT 1800 yards may prevent the unit from synchronizing "180—out." In some receivers it is possible to synchronize 360° out and still be in proper operation. The *So* receiver, which has a value of 40 knots per revolution, will synchronize at either 0 or 40 knots, and the *Rj* receiver will synchronize at 0, IN 4000, IN 8000, or IN 12,000 yards.

Dead space

The dead space, the area with zero torque, can be determined by gently moving the dial of the test synchro and checking the rotor torque. This dead space varies considerably, depending upon whether the lead is entirely open or is merely making poor contact. As the torque increases, the synchro hum also increases.

Direction of rotation

The direction of rotation depends upon whether the test synchro is connected to the instrument wiring or to external ship's wiring. When it is connected to ship's wiring, the correct direction of rotation is counterclockwise for an increasing signal. When it is connected to the instrument wiring, the correct direction of rotation must be obtained from the Navy lead designation charts pasted inside the cover. For example, the lead designation chart shows, for the fine *Co* receiver motor, a clockwise rotation for an increasing signal, so the test synchro should turn clockwise as *Co* is increased.

A locked rotor

If the rotor of the synchro is locked, or appears to be locked at certain positions as the input signal is changed, there may be mechanical jamming of the rotor or a short circuit between the S leads. See *Synchro Receivers*, OP 1140A, and OP 1303.

A short or ground

To locate a short or ground, disconnect the leads at both terminals and megger the leads with respect to each other and with respect to ground. Refer to *Wiring*, OP 1140A.

An open lead

To locate an open lead, touch one of the leads to ground and megger the other end to ground. Refer to *Wiring*, OP 1140A.

NOTES:

Part three

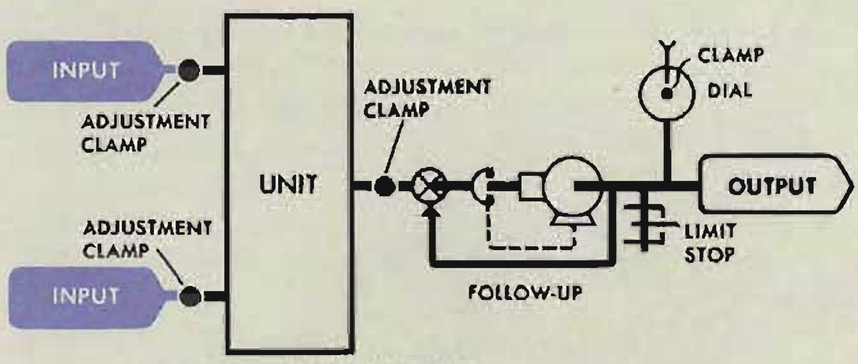
UNIT CHECK TESTS

Table of Contents

UNIT CHECK TESTS

Unit check tests are quick tests of individual computing units or related groups of units. These tests will reveal mechanical defects and adjustment errors in a particular unit, or faulty adjustment of the unit to its input quantities. Unit check tests are used during analysis of A test errors whenever a specific unit or unit network must be checked for error.

These unit check tests are arranged in a definite order so that the procedure in many later tests depends upon obtaining satisfactory results from the earlier tests. Therefore, if several different unit or network checks are made, they should be performed in the order given.



A TYPICAL UNIT NETWORK

RUNNING THE UNIT CHECK TESTS

To run a check test, known input values are set up at the computer and the output values are read on the computer dials or counters. In many cases, the input quantities can be set, and the output quantities can be read, without removing any of the computer covers.

A summary of unit check tests is provided at the end of this chapter. For personnel familiar with the computer, these short tests will be found helpful in making quick unit checks to isolate faulty networks.

UNIT CHECK TEST ERRORS

For each unit check test, the correct output values are given. The actual output values of a unit are compared with the correct values to determine whether that unit is in error. An erroneous output will indicate that one of the elements of the unit being checked is incorrectly positioned.

Such an error may be caused by a faulty input, improper adjustment of the unit to its inputs, mechanical casualties in the unit, or follow-up trouble. Before any adjustments are changed, check the unit for broken parts, sticking, or excessive lost motion and check all follow-ups in the unit network.

If any mechanical casualties are found, refer to *Locating Casualties* and *Removal of Mechanisms* in this OP, and to OP 1140A for repair of the unit.

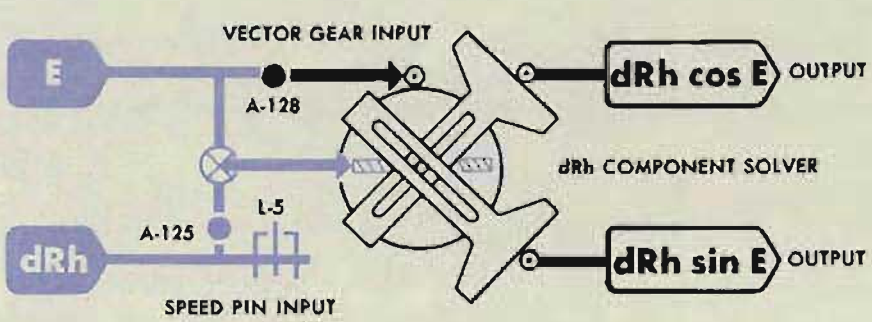
If there are no mechanical troubles but the unit check test indicates an error, check the inputs to the unit and the adjustment of the unit. See *A Test Analysis*, page 90.

CAUTION: Do not make any readjustments until the exact cause for error has been found.

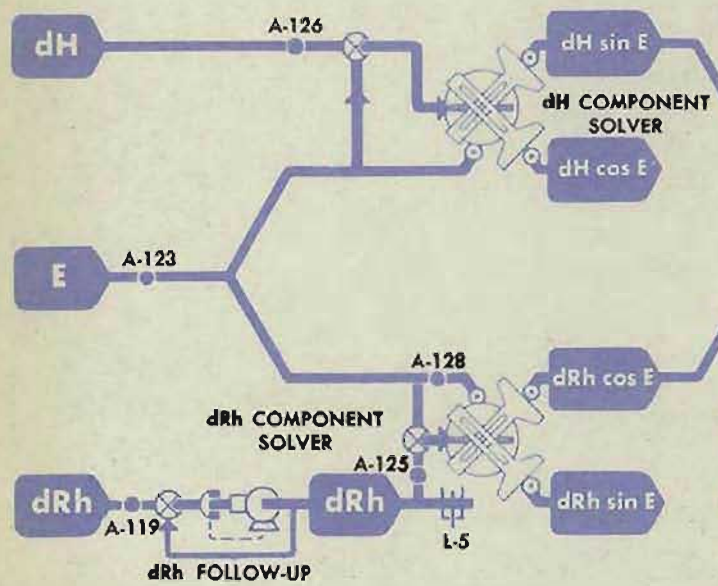
If the error was caused by a slipped clamp, the reason for the slippage should be determined before the clamp is readjusted.

For example: Suppose that the results of tests indicate faulty operation of the *dRh* component solver. The relative motion component solver check test is made, and indicates that the vector gear of the *dRh* component solver is incorrectly positioned. The *dRh* network and component solver are checked for trouble, but no mechanical casualties are found. The A test analysis shows that A-128 is incorrectly adjusted.

It is possible that the clamp on A-128, though seemingly tight, will not hold the adjustment when subjected to excessive overload. Such an overload may occur when the *E* line is run into its limit stop at full speed.



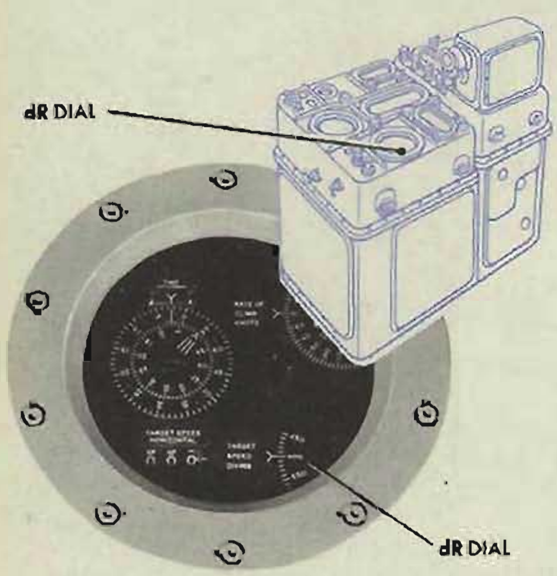
RELATIVE MOTION COMPONENT SOLVERS CHECK TESTS



Turn the power ON.

Turn the control switch to LOCAL.

Set the *dR* handcrank at AUTO.



Check the zero adjustment of the dR Network

1 Set *So*, *Sh*, *dH*, and *E* at 0.
2 Set *Br* and *A* at 90°.
The *dR* dial should read 0.

If the *dR* dial does not read 0°, either the *dRh* component solver lead screw is incorrectly positioned, or the *dR* follow-up and dial adjustment is incorrect.

3 Turn *E* from 0 to 85°.

If the *dR* dial moves toward 0 while *E* is increasing, the *dRh* component solver lead screw is incorrectly positioned. Continue the test to determine the cause of error.

If the *dR* dial does not move, but remains off 0 while *E* is rotated, check A-524, the *dR* follow-up, and the shaft line and gearing to the *dR* dial.

Check the speed pin of the Ship Component Solver

1 Set *E* at 0°.
2 Set *So*, *Sh*, and *dH* at 0.
3 Set *Br* and *A* at 90°.
dR should read 0, if the zero adjustment of the *dR* network is correct.

4 Turn the *Co* handcrank until *Br* reads 0°.
(*A* should remain at 90°.)

The *dR* dial should remain at 0 while *Br* is turned from 90° to 0°.

If the *dR* dial moves off 0, the *So* speed pin is incorrectly positioned.

Check the speed pin of the Target Component Solver

1 Set *E* at 0°.
2 Set *So*, *Sh*, and *dH* at 0.
3 Set *Br* and *A* at 90°.
4 Turn *A* from 90° to 0°.
The *dR* dial should remain at 0 while *A* is turned from 90° to 0°.

If the *dR* dial moves off 0, the *Sh* speed pin is incorrectly positioned.

Check the vector gear of the Ship Component Solver

1 Set *E* at 0°.
2 Set *Br* and *A* at 90°.
3 Set *Sh* at 0 knots.
4 Turn *So* from 0 to 45 knots.
The *dR* dial should not move while *So* is run from 0 to 45 knots.

If the *dR* dial does not remain at 0, the vector gear of the ship component solver is incorrectly positioned.

Check the vector gear of the Target Component Solver

1 Set *E* at 0°.
2 Set *A* and *Br* at 90°.
3 Set *So* at 0 knots.
4 Turn *Sh* from 0 to 400 knots.
The *dR* dial should remain at 0 while *Sh* is run from 0 to 400 knots.

If the *dR* dial does not remain at 0, the vector gear of the target component solver is incorrectly positioned.

Note:
If the *dR* dial reading varies from 0 by only a slight amount, turn the target angle handcrank until the *dR* dial moves back to 0.

Read *A* when *dR* equals zero.

If the *A* dial reading is then off 90° by less than half the width of a dial graduation line, do not adjust the *A* dial until further checks have been made. This apparent slight error may have been introduced purposely to improve C test results.

Check the lead screws of the dH and dRh Component Solvers

1. Set *Br* and *A* at 90°.
2. Set *So*, *Sh*, and *dH* at 0.
3. Turn *E* from 0° to 85°.

   The *dR* dial should remain at 0 while *E* is turned from 0° to 85°.

   If the *dR* dial does not remain at 0, either the *dH* or the *dRh* lead screw is incorrectly positioned.

4. Make sure that *E* is at 85°.
5. Turn the *dH* handcrank until the *dR* dial reads 0.
6. Turn *E* down from 85° to 0°.

   If the *dR* dial reading then remains at 0 while *E* is decreased from 85° to 0°, the *dH* lead screw is incorrectly adjusted to the *dH* dial. The error equals the amount *dH* was turned from 0.

   If the *dR* dial moves off 0 and then returns to a 0 position while *E* decreases from 85° to 0°, the *dRh* lead screw is incorrectly positioned and the zero adjustment of *dR* is incorrect.

Check the vector gear of the dRh Component Solver

1. Set *Br* at 90°.
2. Set *A* at 0°.

Table of Contents

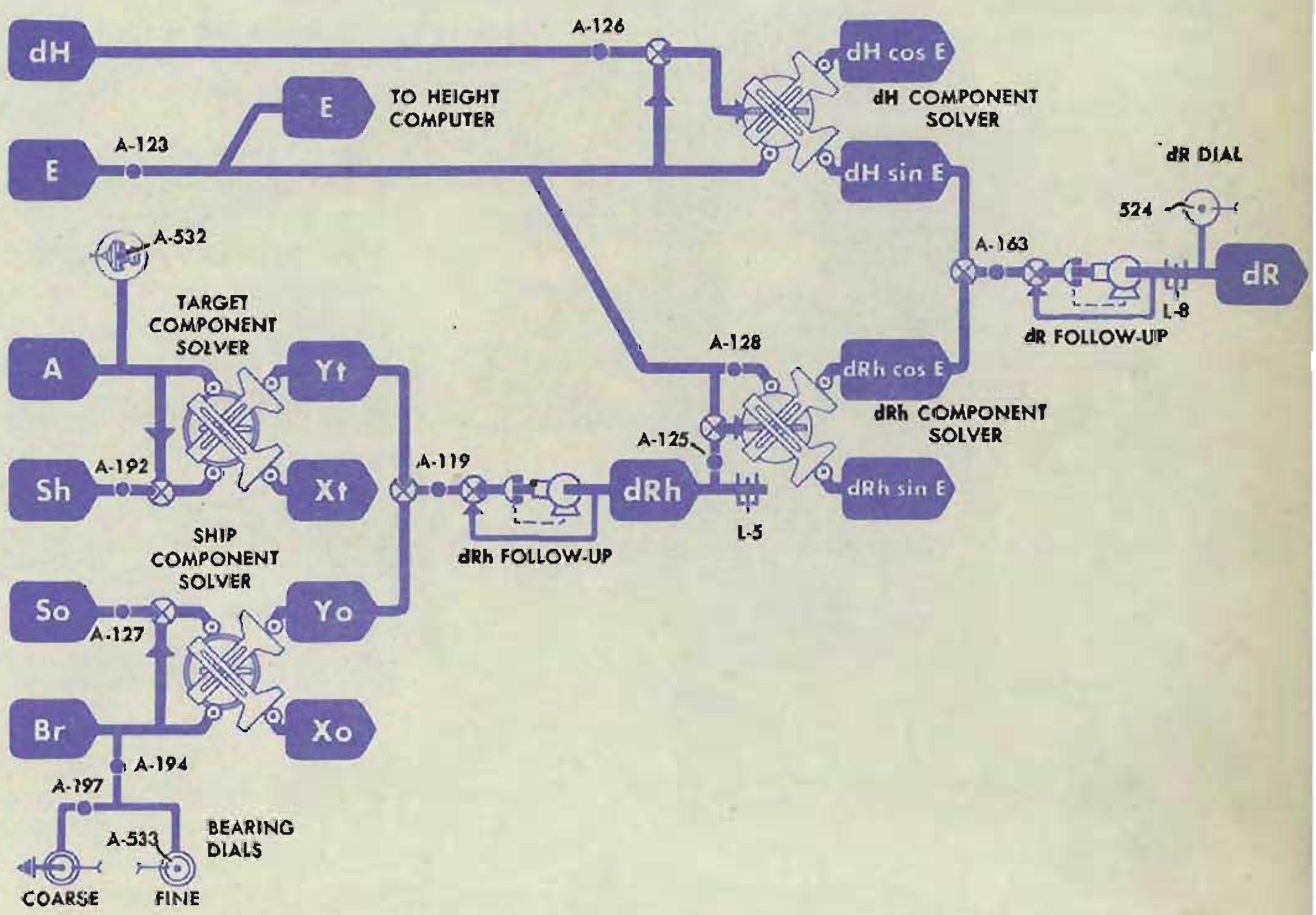
3 Set *So* and *dH* at 0.
4 Set *Sh* at 400 knots.
5 Set *E* at 60°.
The *dR* dial should read −200 knots.

If the *dR* dial does not read −200 knots, the vector gear of the *dRh* component solver is incorrectly positioned.

Check the vector gear of the dH Component Solver

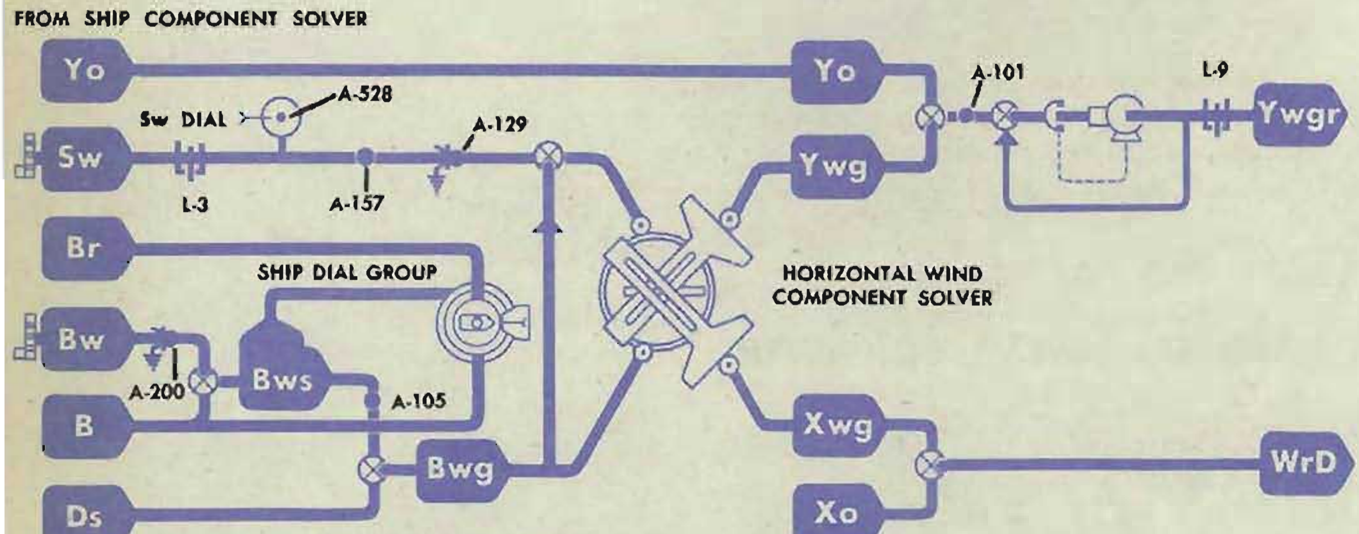
1 Set *Br* and *A* at 90°.
2 Set *So* and *Sh* at 0.
3 Set *E* at 30°.
4 Set *dH* at DIVE 240 knots.
The *dR* dial should read −120 knots.

If the *dR* dial does not read −120 knots, the vector gear of the *dH* component solver is incorrectly positioned.

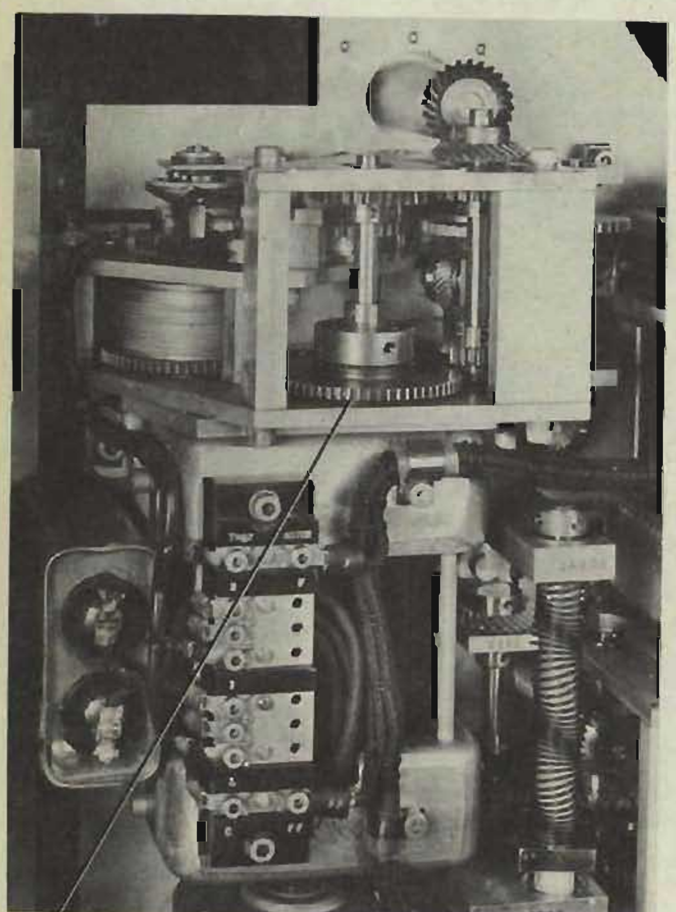


HORIZONTAL WIND COMPONENT SOLVER CHECK TEST

Method A using the Ywgr Follow-up



HORIZONTAL WIND COMPONENT SOLVER NETWORK



OBSERVE Ywgr OUTPUT GEAR FOR MOTION (UNDER COVER 5)

Check the Speed Pin

1. Turn the power ON.
2. Set *Sw* at 0 knots.
3. Mark the *Ywgr* follow-up output gearing for use as an indicator.
4. Turn *Bw* through 360°.

If there is any movement of the *Ywgr* follow-up output gearing during travel of *Bw* through 360°, the speed pin of the horizontal wind component solver is incorrectly positioned. (Allow movement of 5 teeth at friction gear.)

Check the Vector Gear

1. Set *Ds* at 500 mils.
2. Set *Bws* at 90° as follows:
   Set *Co*, *Br*, and *Bw* at 0, carefully lining up *Bw*. Turn *Br* to 90°, bringing the whole dial group around, thus setting *Bws* at 90°.
3. Run *Sw* from 0 to 60 knots.

If there is any movement of the *Ywgr* follow-up output gearing during travel of *Sw* from 0 to 60 knots, the vector gear of the horizontal wind component solver is incorrectly positioned. (Allow movement of 10 teeth at friction gear.)

Method B
using the Star Shell Deflection Counter

Check the Speed Pin

1 Turn the power ON.
2 Set *So*, *Sh*, *Sw* at 0 knots.
3 Remove cover 3 and read the star shell deflection counter.
4 Turn *Bw* through 360°.

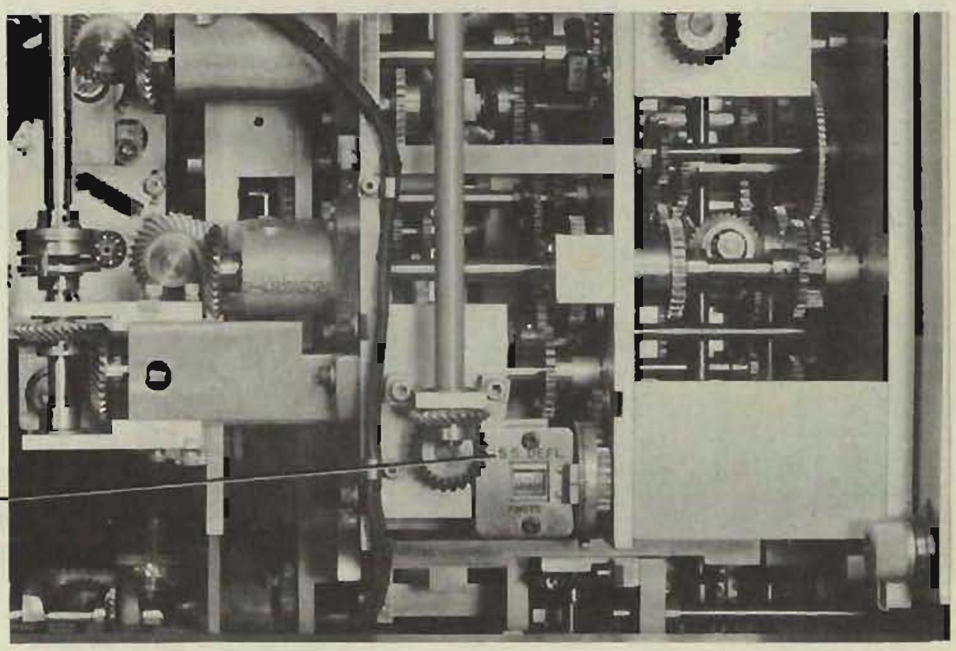
If there is any movement of the star shell deflection counter when *Bw* is turned through 360°, the speed pin of the horizontal wind component solver is incorrectly positioned (Allow 0.1-knot error, i.e., one small division on the counter drum.)

Check the Vector Gear

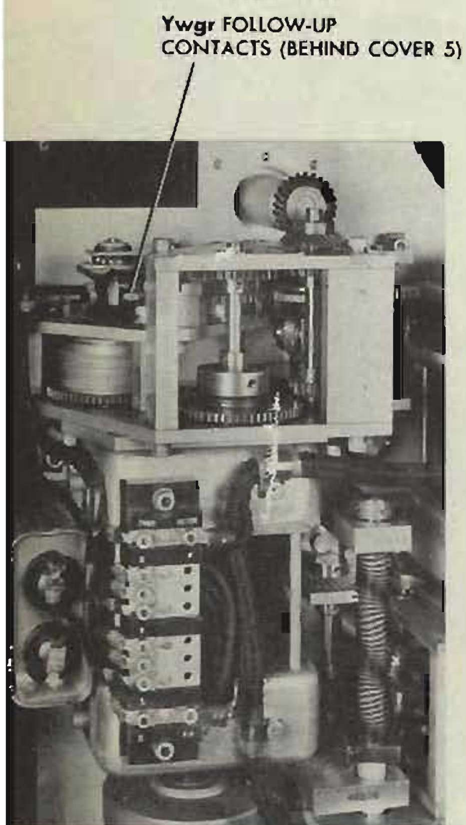
1 Set *Ds* at 500 mils.
2 Set *Bws* at 0° as follows:
Set *Co*, *Br* and *Bw* at 0°, carefully lining up *Bw*, thus setting *Bws* at 0°.
3 Run *Sw* from 0 to 60 knots.

If there is any movement of the star shell deflection counter when *Sw* is run from 0 to 60 knots, the vector gear of the horizontal wind component solver is incorrectly positioned. (Allow 0.2-knot error.)

S.S. DEFLECTION COUNTER (UNDER COVER 3)



ELEVATION WIND COMPONENT SOLVER CHECK TEST



Check the Lead Screw

1. Turn the power ON.
2. Turn the control switch to LOCAL.
3. Set *Br*, *A*, and *Bws* at 90°.
   Set *So*, *Sh*, *Sw*, and *dH* at 0 knots.
   Set *Ds* at 500 mils.
   Set *E2* at 80° with sync *E* handcrank at CENTER.
   Set *dR* at 0 with the *dR* handcrank IN.
   Set *I.V.* at 2550 f.s.
4. Set *cR* at 17,000 yards to give a large value to *Tf*.
   R2 should read approximately 17,000 yards.
5. Turn *E2* from 80° to 0°.
   The reading on the *R2* counter should not change while *E2* is decreased from 80° to 0°.

   If the reading on the *R2* counter changes, the lead screw of the elevation wind component solver is incorrectly positioned.

Check the Vector Gear

1. Set *E2* at 78.95°.
   Put the *Vs* handcrank IN.
2. Offset the contacts of the *Ywgr* follow-up control to run *Ywgr* slowly through its full travel, and observe the *R2* counter.

   If there is any movement of the *R2* counter during full travel of *Ywgr*, the vector gear of the elevation wind component solver is incorrectly positioned.

CAUTION:
Do not run the *Ywgr* follow-up by offsetting the contacts if the lead screw and limit stop are not correctly adjusted.

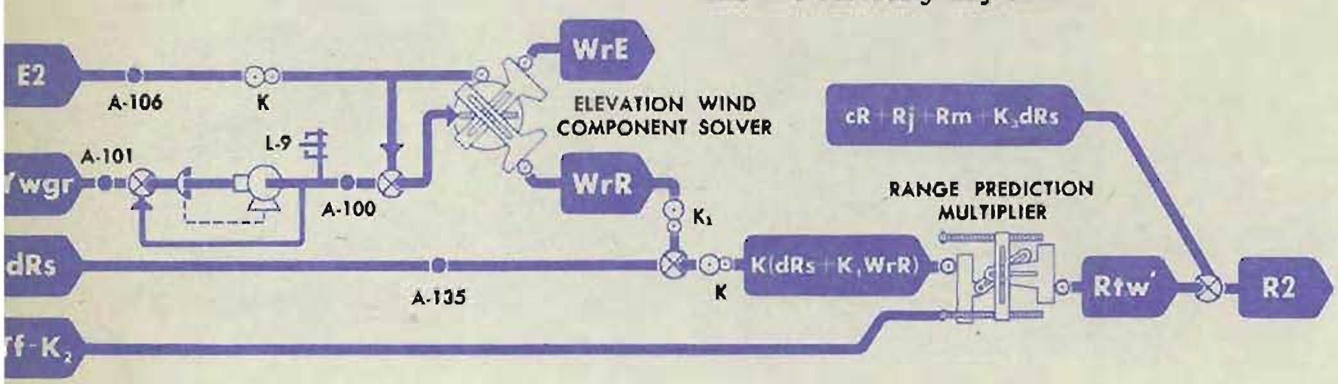


 Table of Contents

HEIGHT COMPUTER CHECK TEST

Check the Height Dials

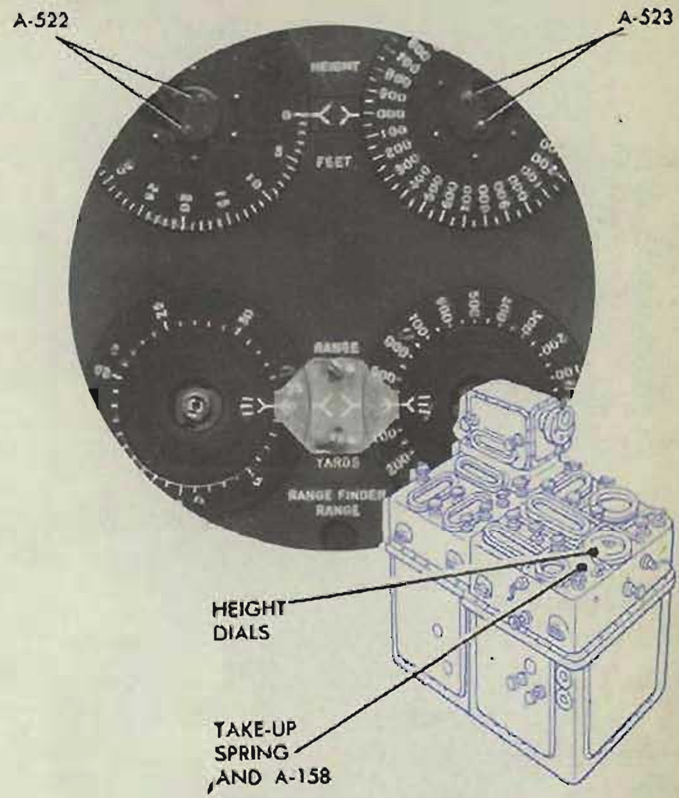
1 Turn the power ON.
2 Set *E* at 0°.
3 Set *cR* at 0 yards.

The height dials should read 0000 feet.

If the height dials do not read 0000 feet:

1 Check the gearing for sticks.
2 Check the dials for binding against the dial mask.
3 Check the tension on the take-up spring. See readjustment of A-158 on page 402 before attempting to change the spring tension.

If the spring has sufficient tension, and there are no sticks in the gearing, check A-522 and A-523.

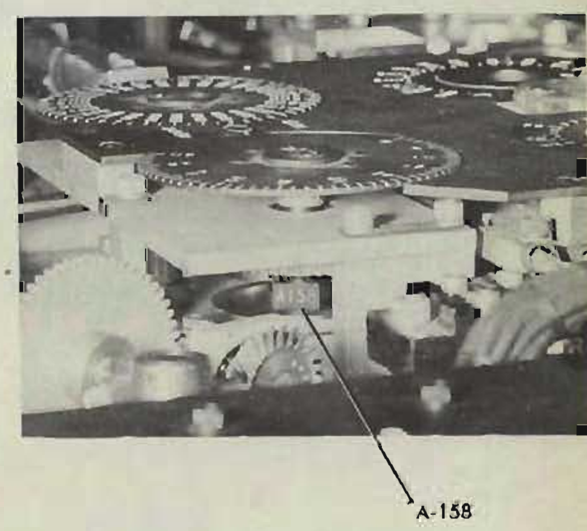


Check the Vector Gear

1 Set *E* at 0°.
2 Turn *cR* from 0 to 35,000 yards (the upper limit of *cR*).

The height dials should read 0000.

If the height dials do not read 0000, the vector gear of the height computer is incorrectly positioned.

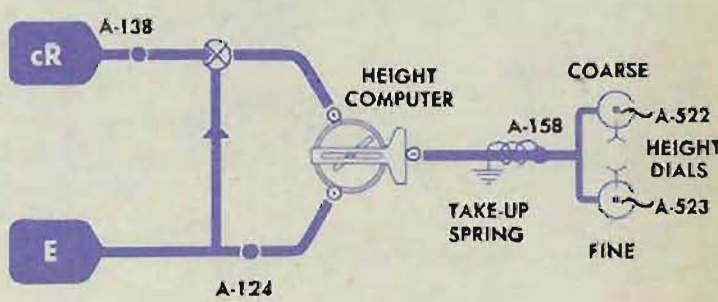


Check the Cam

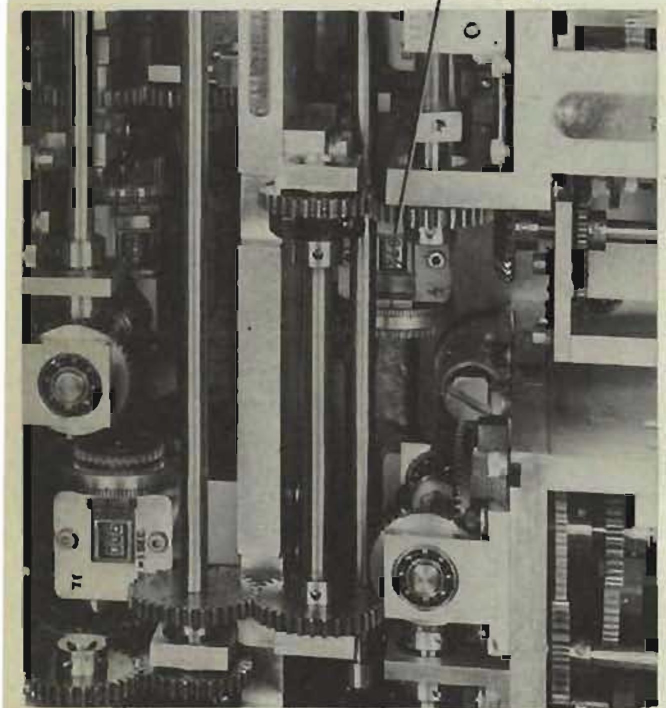
1 Set *E* at 30°.
2 Set *cR* at 10,000 yards.

The height dials should read 15,000 feet.

If the height dials do not read 15,000 feet, the cam of the height computer is incorrectly positioned.



COMPLEMENTARY ERROR CORRECTOR CHECK TEST



1 Turn the power ON.

2 Pull the *Vs* handcrank OUT.
Set *So*, *Sh*, *Sw*, and *dH* at 0 knots.
Set *I.V.* at 2550 f.s.
Set *Vj* at 0.
Set *Ds* at 500 mils.
Set *E2* at 80.00° with the sync *E* handcrank at CENTER.

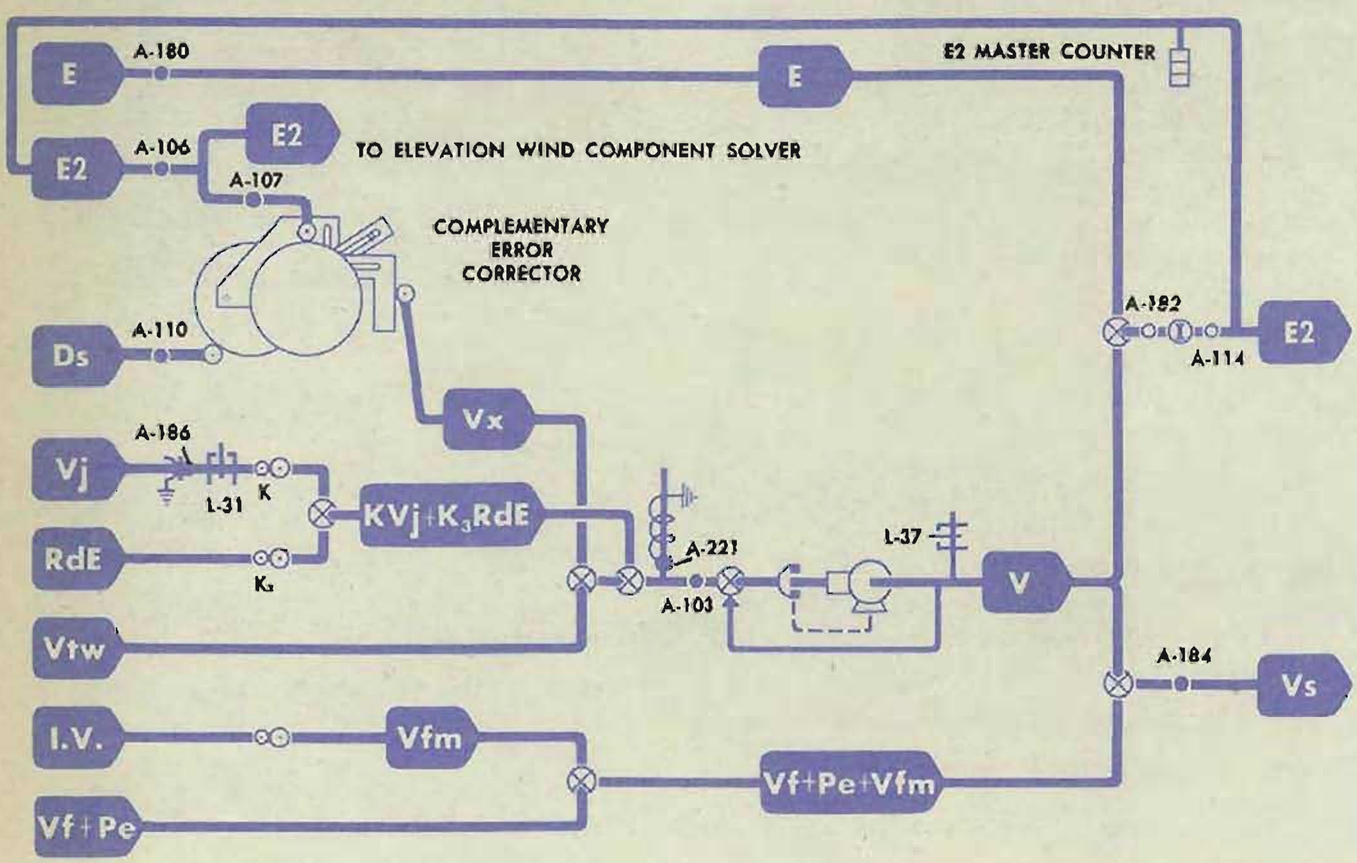
3 Decrease *Ds* until the *Ds* counter reads 100 mils. Then read the *E2* counter and record the reading.

4 Increase *Ds* until the *Ds* counter reads 900 mils. Again read the *E2* counter and record the reading.

Compare the readings of *E2* obtained in steps 3 and 4. If the readings are not equal, the *Ds* cam is incorrectly positioned. (Allow 0.05° difference.)

The readings of *E2* obtained in steps 3 and 4 should be 67.25°. However, if they are equal to each other, but are not 67.25°, the *E2* cam is incorrectly positioned. (Allow ± 0.05° error in *E2*.)

COMPLEMENTARY ERROR CORRECTOR NETWORK



RANGE RATE CORRECTOR CHECK TEST

1 Turn the power ON.

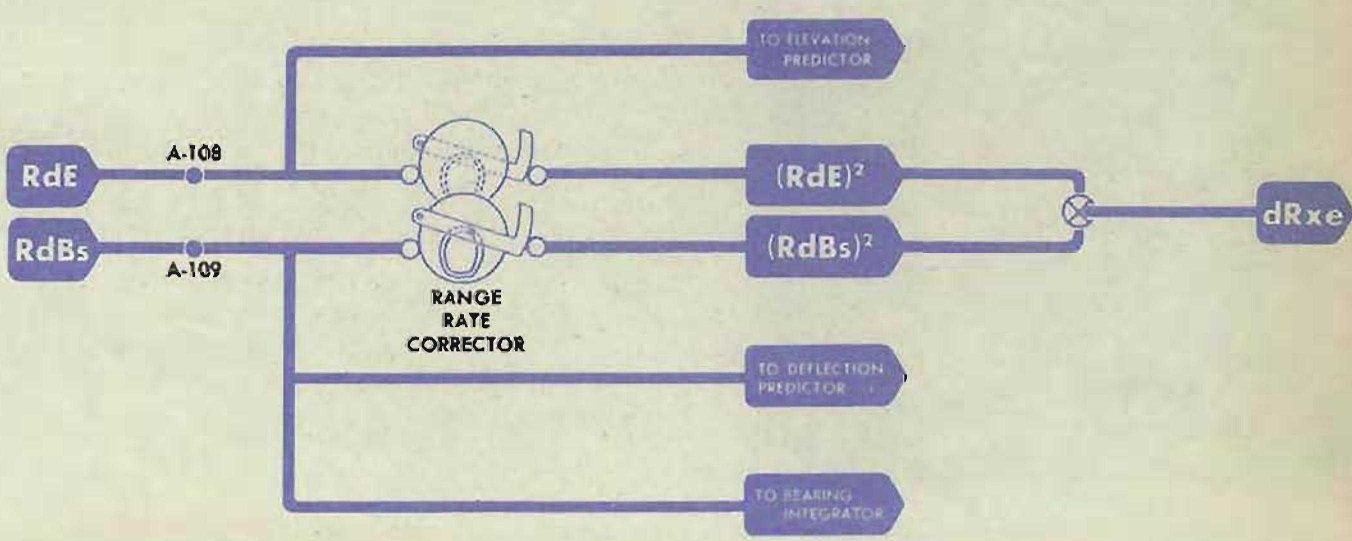
2 Set *So*, *Sh*, and *dH* at 0.

3 Insert a 1/16-inch diameter setting rod through the holes in both cams, both followers, and the mounting plate. The rod should enter to a depth of 2 inches.

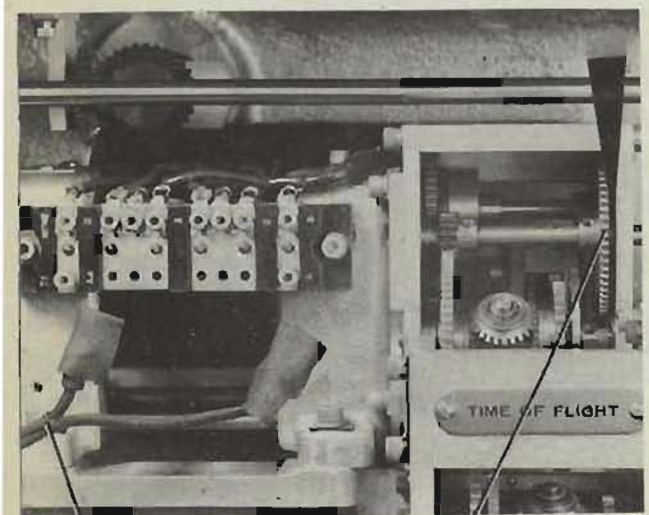
If the setting rod cannot be inserted through the $(RdE)^2$ cam, the *RdE* input is incorrectly positioned.

If the setting rod cannot be inserted through the $(RdBs)^2$ cam, the *RdBs* input is incorrectly positioned.

CAUTION:
DO NOT DISTURB ANY COMPUTER SETTING WHILE THE SETTING ROD IS INSERTED, OR THE UNIT MAY BE DAMAGED. REMOVE THE SETTING ROD WHEN THE CHECK TEST IS COMPLETED.



RANGE PREDICTION MULTIPLIER CHECK TEST



POWER LEADS A AND AA REMOVED

Tf FOLLOW-UP OUTPUT GEARING WEDGED

Preliminary check

1 Remove power leads A and AA from the *Tf* follow-up. Turn the output gearing to set the *Tf* counter at 5.00 sec. (050) and wedge the line.

2 Turn the power ON.

3 Turn the control switch to LOCAL.

4 Set *Br*, *A*, and *Bws* at 90°.
Set *E* at 0°.
Set *So*, *Sh*, *Sw*, *dH*, and *Rj* at 0.
Set *I.V.* at 2550 f.s.
Set *Ds* at 500 mils.
Turn the *dR* handcrank to AUTO.
Set *cR* at 8000 yards.
R2 should read 8000 yards. Record the actual reading.

If the *R2* indicating counter does not read 8000 yards, check all *R2* counters and the *R2* follow-up control. (Refer to *A Test Analysis*, page 122.)

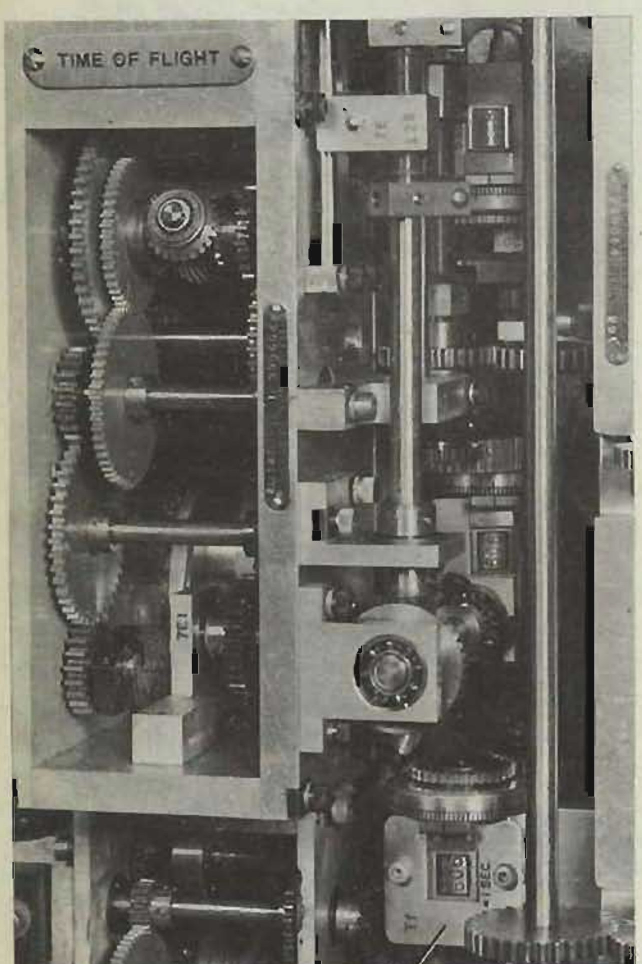
Checking the Range Prediction Multiplier

1 Remove the wedge and turn the *Tf* follow-up output gearing until the *Tf* counter reads 20.00 sec. Rewedge.

2 Check the previously made settings.

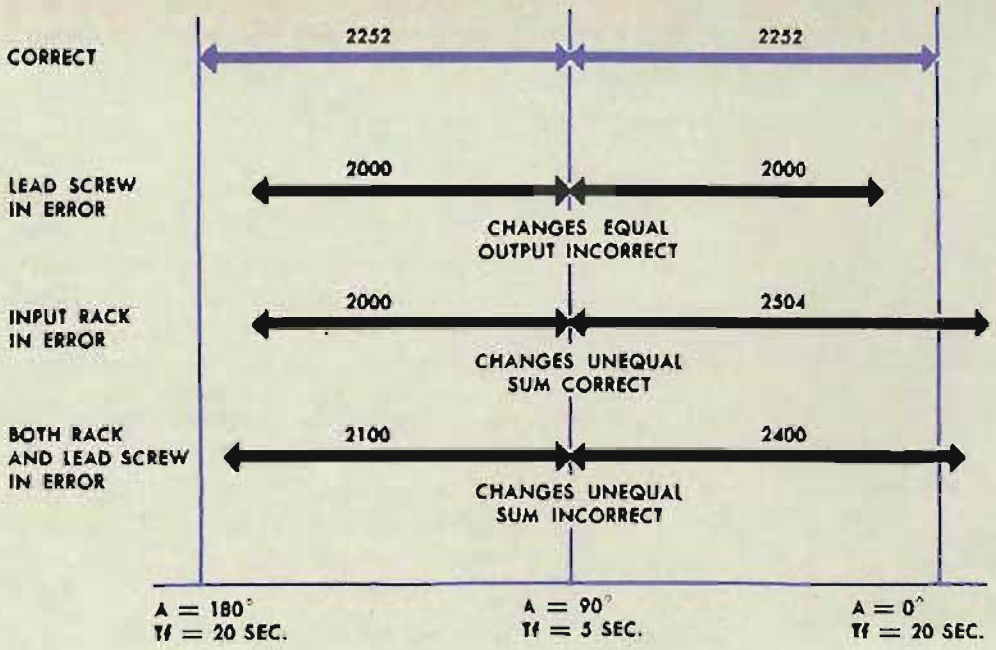
Change *A* to 0°.
Change *Sh* to 200 knots.
R2 should decrease 2252 yards to make the *R2* counter read 5748 yards. Record the actual change from the reading taken in step 4 above.

3 Turn *A* from 0° to 180°.
The *R2* counter should now read 10,252 yards (2252 yards more than 8000). Record the actual change from the reading taken in step 4 above.



Tf COUNTER

CHANGES IN R2



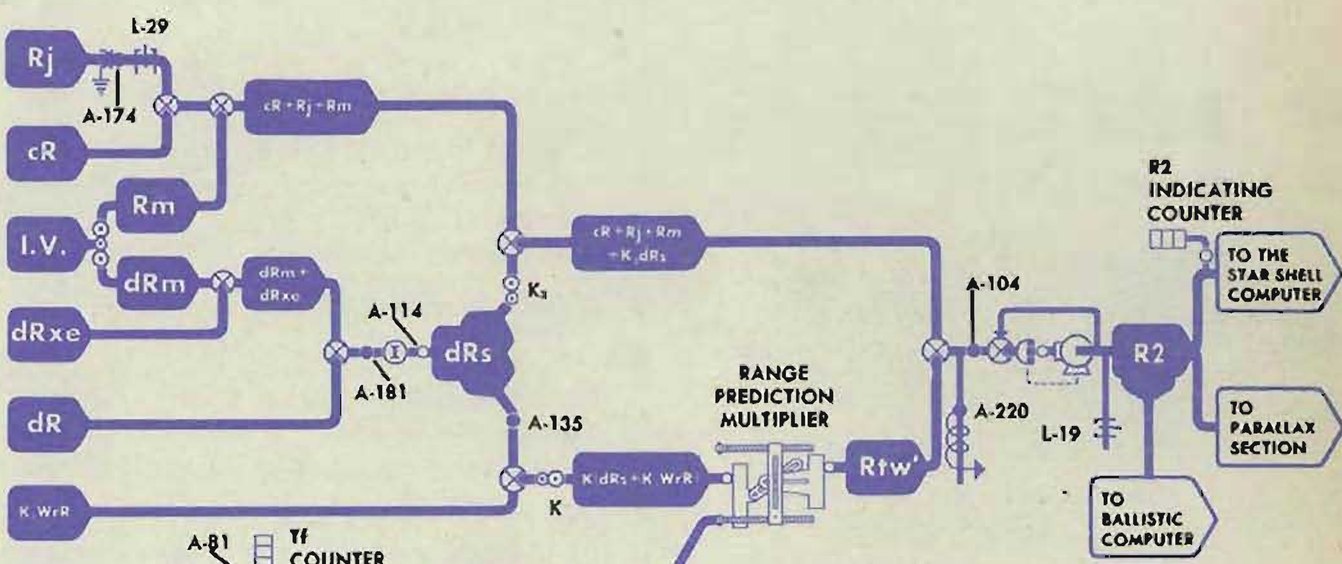
If both changes in *R2* are not equal to 2252 yards, either the input rack, or the lead screw, or both, may be in error.

If the changes are equal, but greater or less than 2252 yards, the lead screw is incorrectly positioned.

If the sum of the two changes is 4504 but the changes are unequal, the input rack is incorrectly positioned.

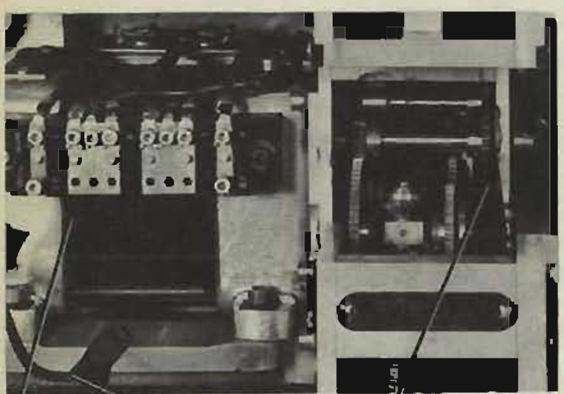
If the sum of the changes is greater or less than 4504 yards, and the changes are unequal, both the input rack and the lead screw are incorrectly positioned.

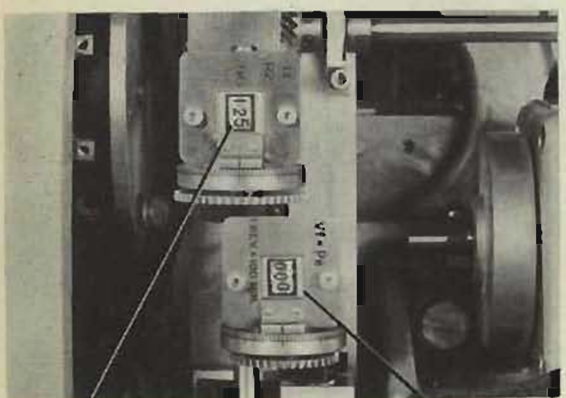
Remove the wedge from the *Tf line*, and reconnect the power leads on the follow-up.

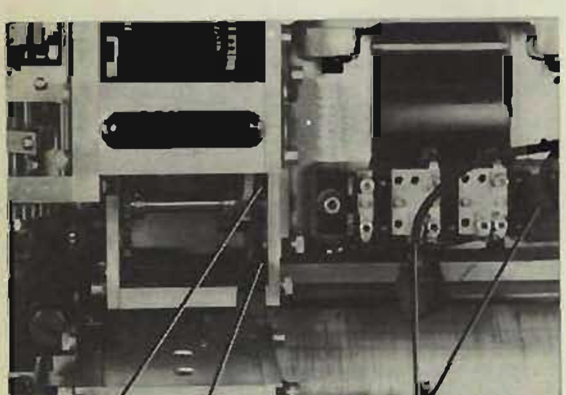


RANGE PREDICTION MULTIPLIER NETWORK

ELEVATION PREDICTION MULTIPLIER CHECK TEST







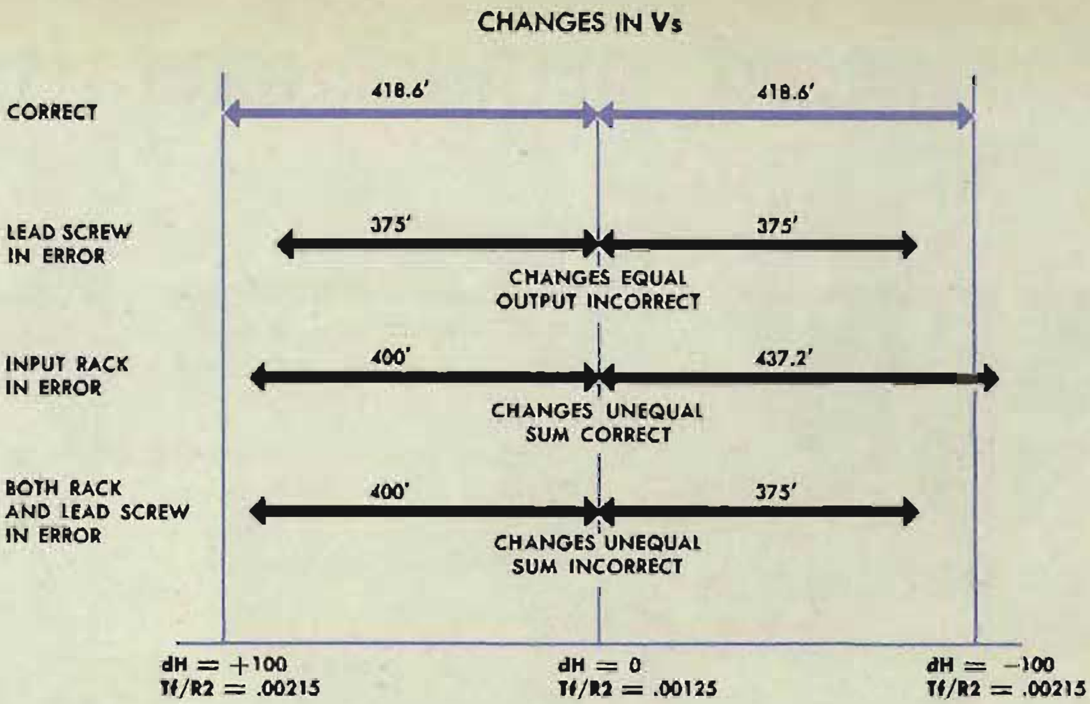
Preliminary check

1. Remove the power leads C1 and CC on the *Vf* + *Pe* follow-up. Turn the output gearing to set the *Vf* + *Pe* counter at 0, and wedge the line.
2. Remove the power leads B and BB from the *Tf/R2* follow-up. Turn the output gearing to set the *Tf/R2* counter at .00125 and wedge the line.
3. Turn the power ON.
4. Turn the control switch to LOCAL.
5. Set *So*, *Sh*, *Sw*, and *Vj* at 0.
   Set *Br*, *A*, and *Bws* at 90°.
   Set *E* at 0°.
   Set *dH* at 0 knots.
   Set *I.V.* at 2550 f.s.
   Set *Ds* at 500 mils.
   Pull the *Vs* handcrank OUT.
   The *Vs* indicating counter should read 2000′.
   Record the actual reading.

   If the *Vs* indicating counter does not read 2000′, check the *V* follow-up, A-103, and A-55.

Checking the Elevation Prediction Multiplier

1. Remove the wedge and turn the *Tf/R2* follow-up output gearing to set the *Tf/R2* counter at .00215.
   Rewedge the line.
2. Check the previously made settings.
3. Set *dH* at +100 knots.
   Vs should increase 418.6′ (the *Vs* counter should read 2418.6′). Record the change from the reading obtained in step 5 above.
4. Set *dH* at −100 knots.
   Vs should decrease 418.6′ (the *Vs* counter should read 1581.4′). Record the change from the reading obtained in step 5 above.



If both changes in *Vs* are not equal to 418.6′, either the input rack or the lead screw, or both, may be in error.

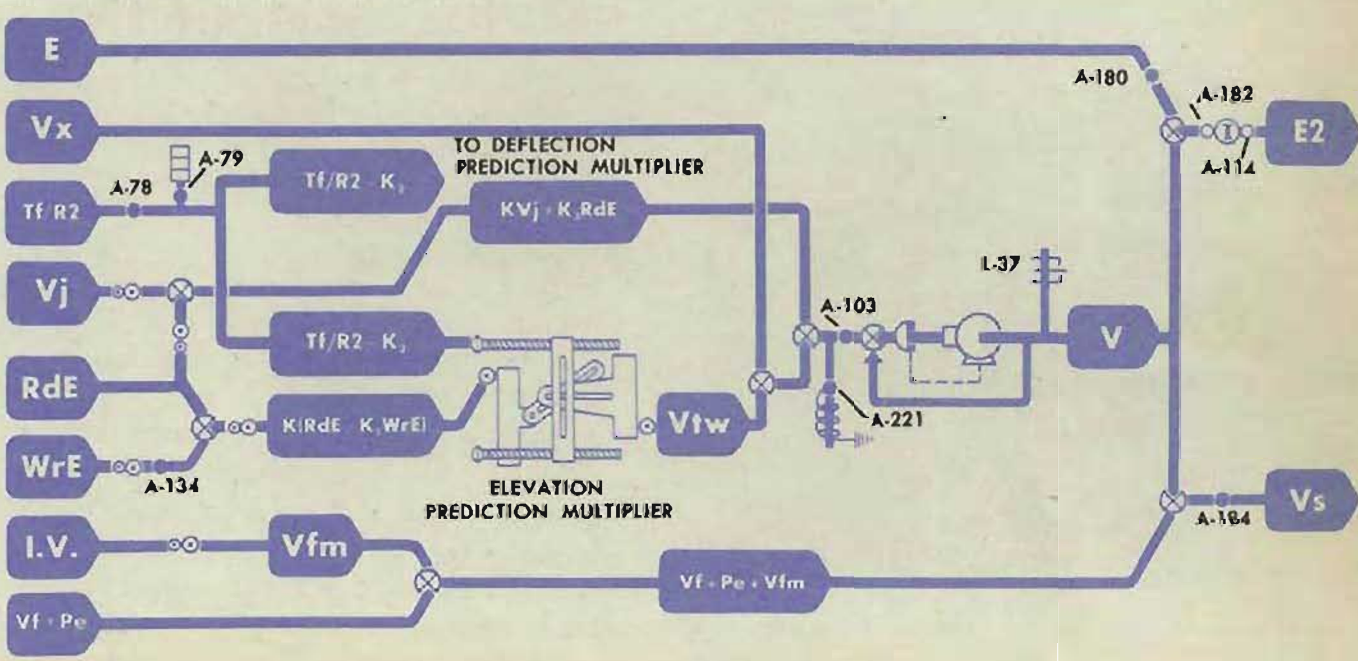
If the changes are equal, but greater or less than 418.6′, the lead screw is incorrectly positioned.

If the sum of the two changes is 837.2′, but the changes are unequal, the input rack is incorrectly positioned.

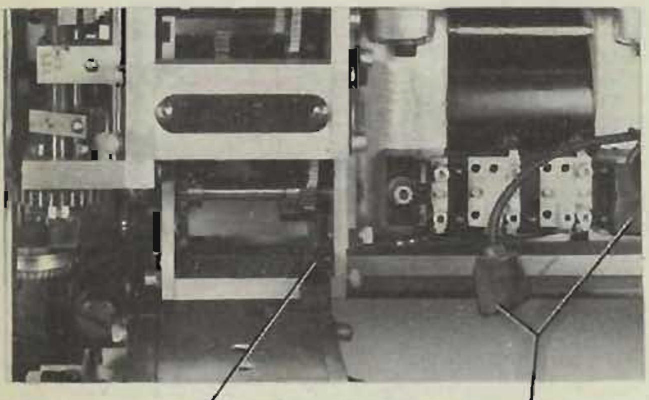
If the sum of the changes is greater or less than 837.2′, and the changes are unequal, both the input rack and the lead screw are incorrectly positioned.

Remove the wedges from the *Vf + Pe* and *Tf/R2* lines, and reconnect the power leads on both follow-ups.

ELEVATION PREDICTION MULTIPLIER NETWORK

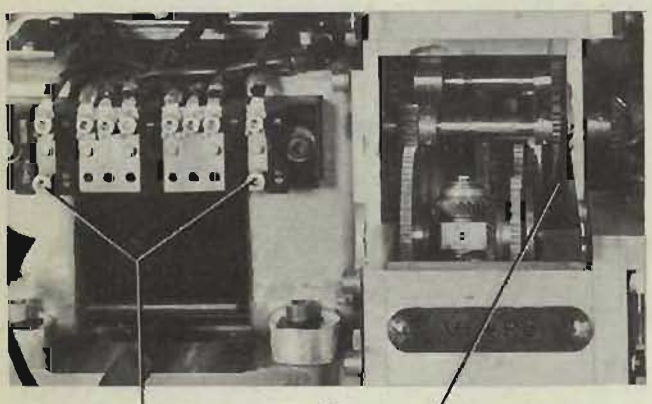


DEFLECTION PREDICTION MULTIPLIER CHECK TEST



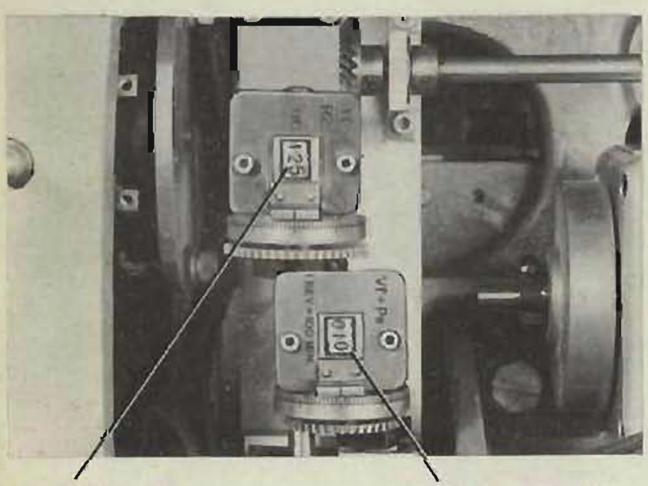
Tf R2 FOLLOW-UP OUTPUT GEARING WEDGED

POWER LEADS B AND BB REMOVED



POWER LEADS C1 AND CC REMOVED

Vf+Pe FOLLOW-UP OUTPUT GEARING WEDGED



Tf/R2 COUNTER READING .00125

Vf+Pe COUNTER READING 100 MIN.

Preliminary check

1 Remove power leads C1 and CC on the *Vf + Pe* follow-up. Turn the output gearing until the *Vf + Pe* counter reads 100′ (010) and wedge the line.

2 Remove power leads B and BB from the *Tf/R2* follow-up. Turn the *Tf/R2* line until the *Tf/R2* counter reads .00125 and wedge the line.

3 Turn the power ON.

4 Turn the control switch to LOCAL.

5 Set *Br*, *A*, and *Bws* at 0°.
Set *So*, *Sh*, *Sw*, and *Dj* at 0.
Set *I.V.* at 2550 f.s.
Pull the *Ds* handcrank OUT.
The *Ds* counter should read 500 mils.
Record the reading.

If the *Ds* counter does not read 500 mils, check A-89, A-102, and the *Dtwj* follow-up.

Checking the Deflection Prediction Multiplier

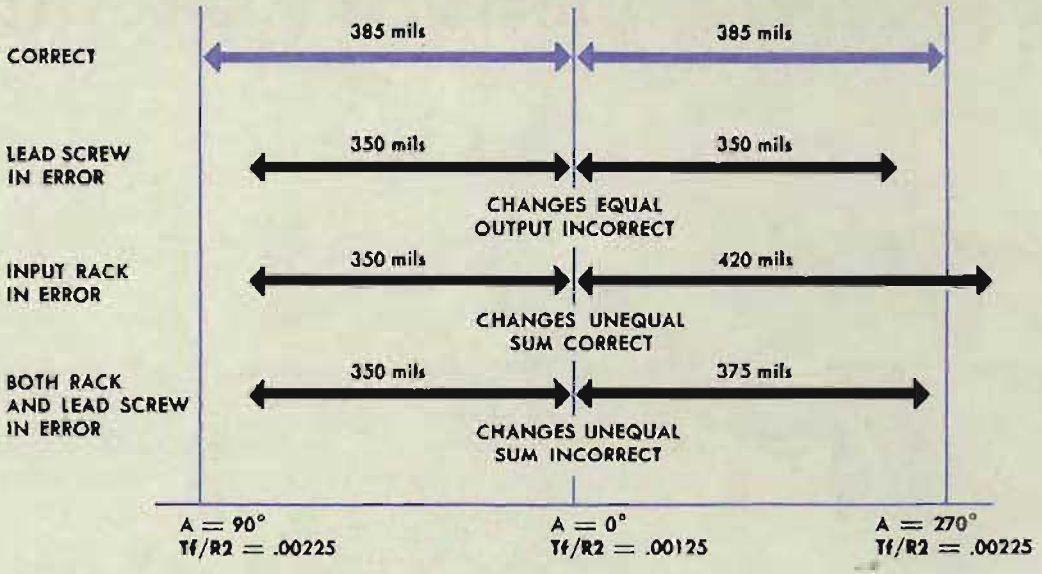
1 Remove the wedge and turn the *Tf/R2* line until the *Tf/R2* counter reads .00225, and rewedge.

2 Set *Sh* at 300 knots.

3 Turn *A* from 0° to 90°.
Ds should increase 385 mils. (The *Ds* counter should read 885 mils.) Record the change from the reading obtained in step 5 above.

Turn *A* from 90° to 270°. *Ds* should return to 500 mils and then decrease 385 mils. (The *Ds* counter should read 115 mils.) Record the change from the reading obtained in step 5 above.

CHANGES IN Ds



If both changes in *Ds* are not equal to 385 mils, either the input rack, or the lead screw, or both, may be in error.

If the changes are equal, but greater or less than 385 mils, the lead screw is incorrectly positioned.

If the sum of the two changes is 770 mils, but the changes are *unequal*, the input rack is incorrectly positioned.

If the sum of the changes is greater or less than 770 mils, and the changes are unequal, both the input rack and the lead screw are incorrectly positioned.

Remove the wedges from the *Vf + Pe* and *Tf/R2* lines, and reconnect the power leads on both follow-ups.

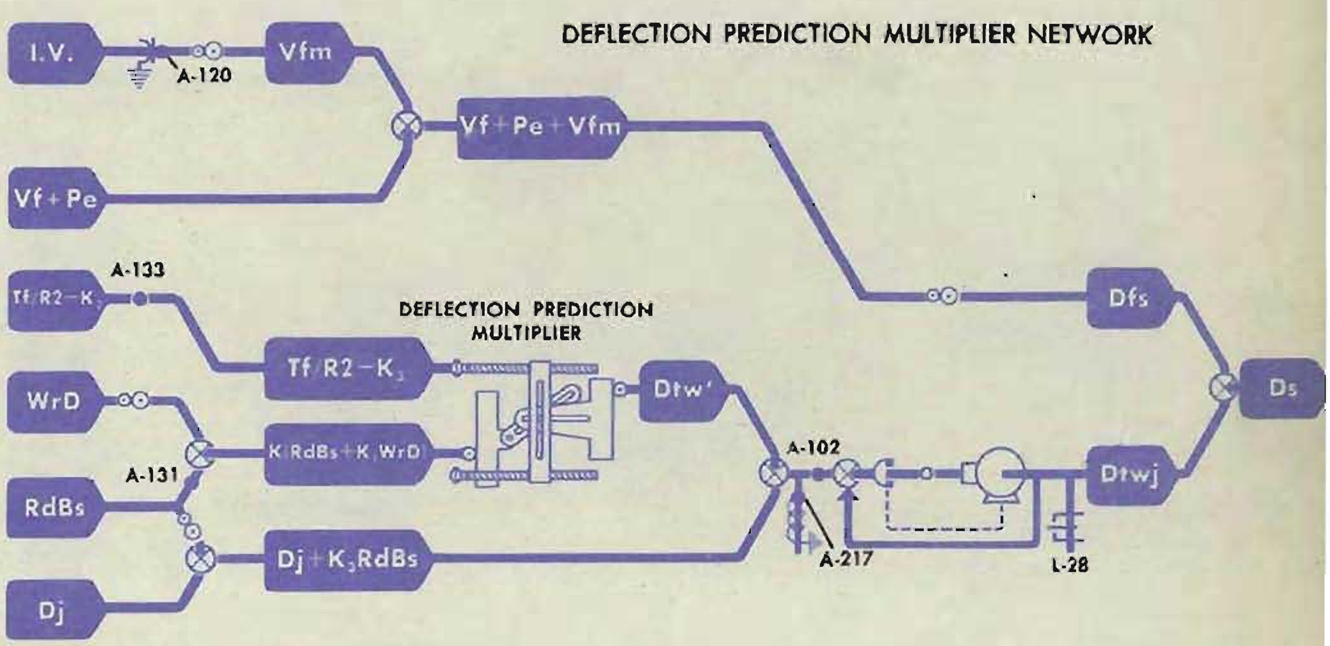
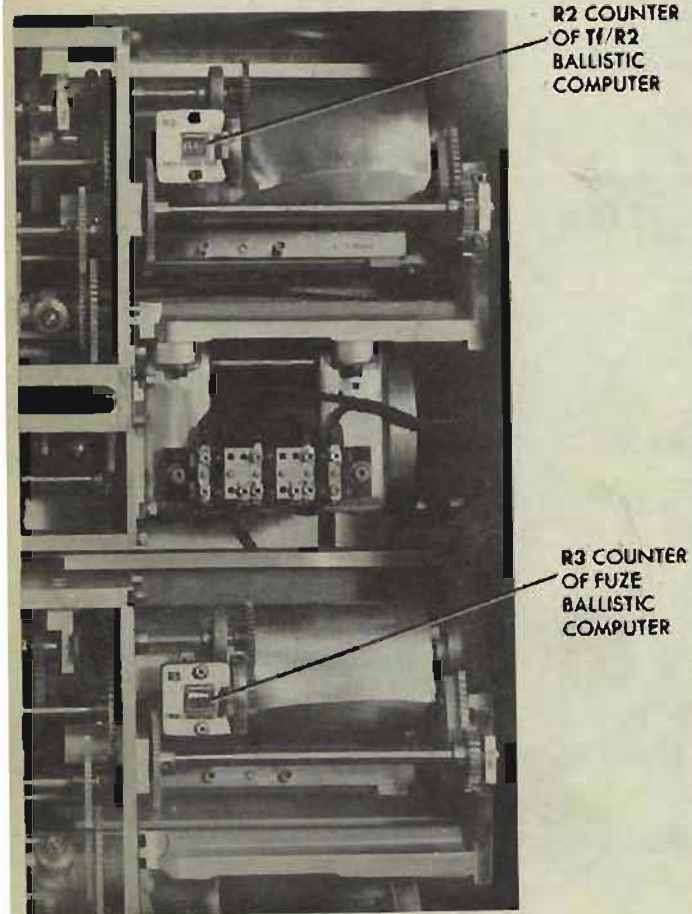


Table of Contents

DEAD TIME PREDICTION MULTIPLIER CHECK TEST



Preliminary check

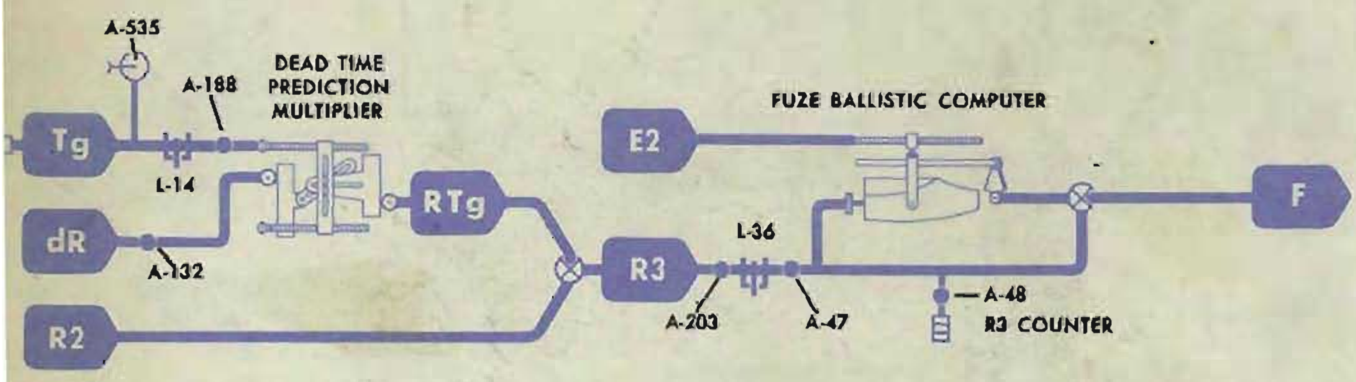
1 Turn the power ON.
2 Set the *dR* handcrank at AUTO.
3 Set *So*, *Sh*, and *dH* at 0.
4 Set *Tg* at 0.
5 (Ser. Nos. 781 and higher.) Set *I.V.* at 2500 f.s.
6 (Ser. Nos. 781 and higher.) Disconnect the power leads on the fuze ballistic computer follow-up, and set *F* equal to *Tf*.

The *R3* counter in the fuze ballistic computer should agree with the *R2* counters. If the *R3* and *R2* counters do not agree, check the input rack and the lead screw of the dead time prediction multiplier.

Check the Input Rack

1 Using the generated range crank, set *R3* at 3000 yards.
2 Turn *Tg* to 6 seconds.
3 (Ser. Nos. 781 and higher.) Increase *F* to its upper limit of travel.

The value on the *R3* counter should not change while *Tg* or *F* is increased. If it does change, the input rack of the dead time prediction multiplier is incorrectly positioned.



SER. NOS. 780 AND LOWER

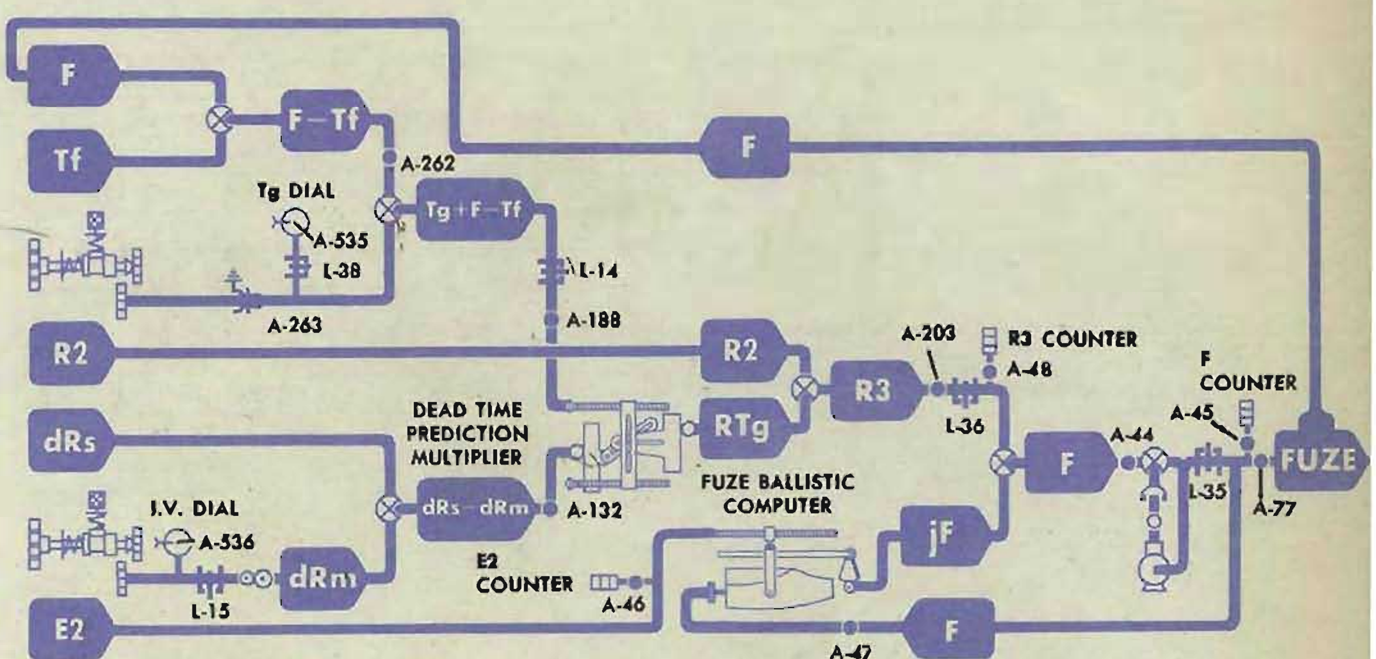
Check the Lead Screw

1. Set *Tg* at 0 seconds.
2. Disconnect the power leads from the *R2* follow-up, and wedge *R2* at 3000 yards.
3. (Ser. Nos. 781 and higher.) Set *F* equal to *Tf*.
4. With the *dR* handcrank IN, turn the *dR* line from —450 knots to +450 knots.

The value on the *R3* counter should not change while *dR* is turned. If it does change, the lead screw of the dead time prediction multiplier is incorrectly positioned.

After the multiplier check is completed, remove all wedges and replace the power leads on the *F* and *R2* follow-ups.

If the dead time prediction multiplier shows no errors, check A-203.



SER. NOS. 781 AND HIGHER

BALLISTIC COMPUTER CHECK TESTS

The four ballistic computer units are:

The $Vf + Pe$ ballistic computer
The $Tf/R2$ ballistic computer
The Tf ballistic computer
The Fuze ballistic computer

Test data required for making the ballistic computer check tests may be obtained from the record of N.I.O. factory acceptance tests supplied with each instrument. A sample test form is shown below.

COMPUTER MK. I
MOD. 7, 11, 13

RESTRICTED

ORD. SK. 104371-5
FICO DRG. NO. 36096-5

BALLISTIC COMPUTER TEST
TIME OF FLIGHT (SEC.)

R2	600 YDS.			3000 YDS.			6000 YDS.			8000 YDS.		
E2	CALC.	READ.	ERROR	CALC.	READ.	ERROR	CALC.	READ.	ERROR	CALC.	READ.	ERROR
0°	0.73			4.14			9.92			15.07		
30°	0.74			4.24			10.41			15.94		
50°	0.74			4.28			10.54			16.23		
70°	0.74			4.29			10.53			16.24		
TOTAL ERROR												

R2	10000 YDS.			12000 YDS.			14000 YDS.			16000 YDS.		
E2	CALC.	READ.	ERROR	CALC.	READ.	ERROR	CALC.	READ.	ERROR	CALC.	READ.	ERROR
0°	21.22			28.37			36.54			46.47		
30°	22.78			31.47								
50°	23.48			34.16								
70°	23.75											
TOTAL ERROR												

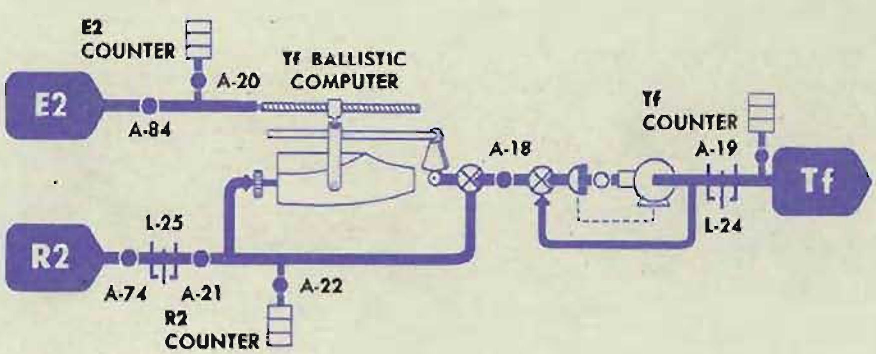
GRAND TOTAL ERRORS(25)		
ALLOW. .02	AVG. ERROR	
ALLOW. .02	MAJ. ERROR	
ALLOW. .06	MAX. ERROR	

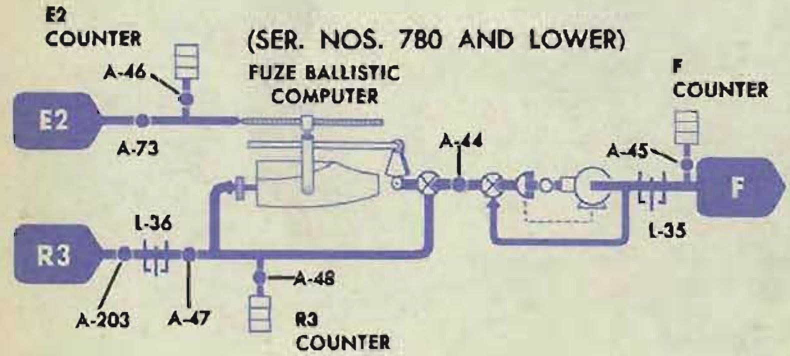
N.I.O. LIMITS

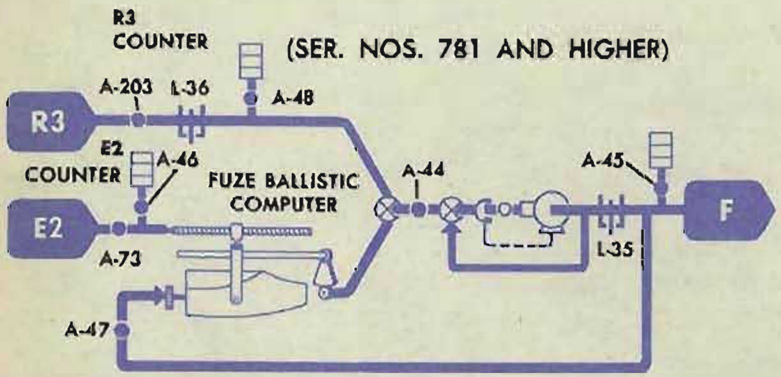
Checking the Ballistic Computer

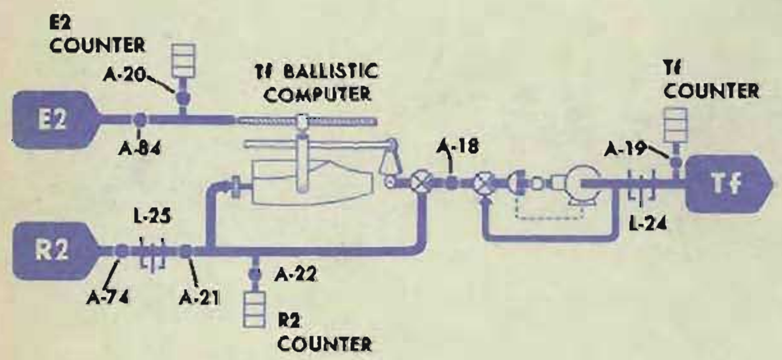
The check tests of all four ballistic units are made in the same manner, except that the input and output values are read on the counters in the particular unit being checked. The procedure for making the *Tf* ballistic computer check test is given below:

1 Remove cover 4.
2 Turn the power ON.
3 Set the *E2* check counter in the *Tf* ballistic unit at 0.00° with the sync *E* handcrank at CENTER.
4 Set the *R2* check counter in the *Tf* ballistic unit at 600 yards. Because changing *R2* may change *E2*, check *E2* after each setting of *R2*.
5 Read and record the value of *Tf*.
6 Set *R2* at 3000 yards, 6000 yards, etc., as indicated on the test form.
7 Read and record the value of *Tf* for each setting of *R2*.
8 Complete the unit test with *E2* at 30°, 50°, and 70°.
9 Compute the errors by comparing each reading with its calculated value.
10 Calculate the average, majority, and maximum errors.
11 Compare the average, majority, and maximum errors with the allowable limits.









Correcting the errors

If the errors greatly exceed the allowable limits, check the ballistic computer for mechanical troubles. Refer to *Ballistic Computers*, OP 1140A. Check the ballistic computer follow-up.

If the errors exceed the allowable limits by a small amount, the ballistic computers can usually be readjusted without removal.

If the errors are constant (same magnitude and same sign) proceed as follows:

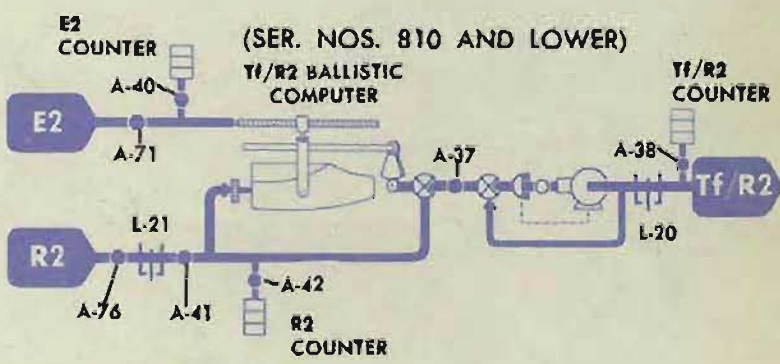
For the Fuze ballistic unit, in computers with Ser. Nos. 780 and lower, check A-44 and A-45. In computers with Ser. Nos. 781 and higher, check A-45.

For the *Tf* ballistic unit, check A-18 and A-19.

For the *Tf/R2* ballistic unit, check A-37 and A-38.

For the *Vf* + *Pe* ballistic unit, check A-13 and A-14.

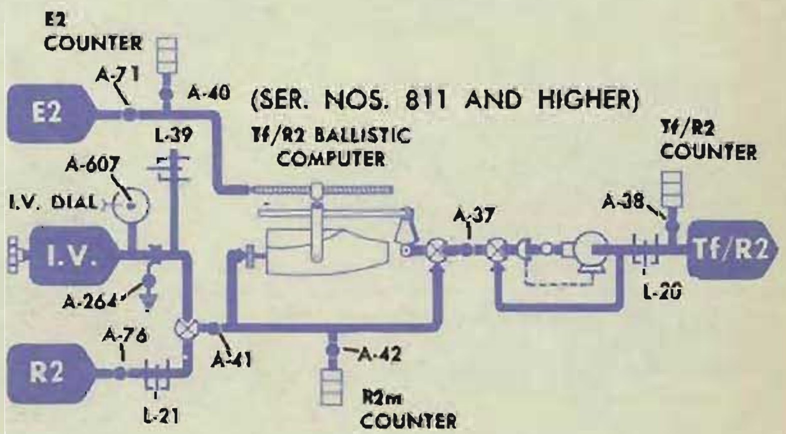
If the errors change progressively as *R2* (or *R2m* or *R3*) is changed while *E2* is kept constant, proceed as follows:



For the Fuze ballistic unit in computers with Ser. Nos. 780 and lower, check A-48. In computers with Ser. Nos. 781 and higher, check A-47 and A-44.

For the *Tf* ballistic unit, check A-22.

For the *Tf/R2* ballistic unit, check A-42.



For the *Vf* + *Pe* ballistic unit, check A-17.

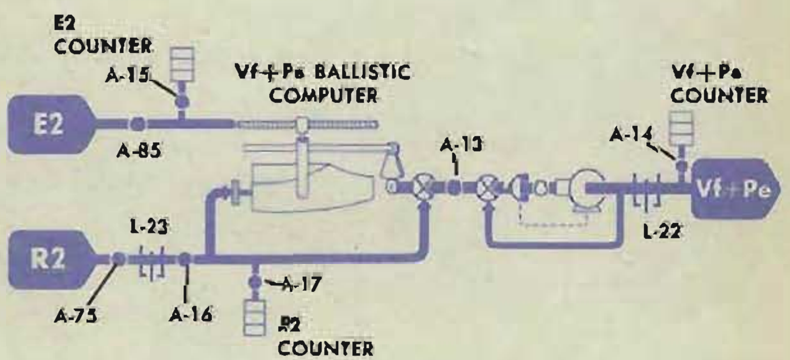
If the errors change progressively as *E2* is changed while *R2* is kept constant, proceed as follows:

For the Fuze ballistic unit, check A-46.

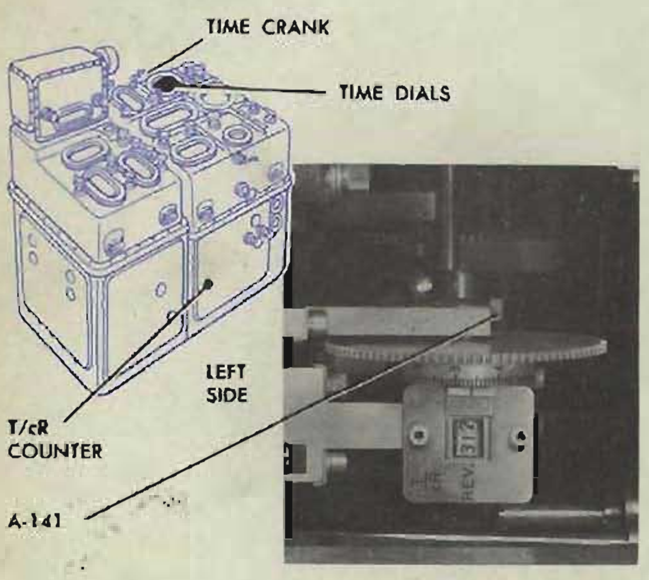
For the *Tf* ballistic unit, check A-20.

For the *Tf/R2* ballistic unit, check A-40.

For the *Vf* + *Pe* ballistic unit, check A-15.



T/cR INTEGRATOR CHECK TEST



T/cR COUNTER READS 312.34 AT START OF TIME INTERVAL

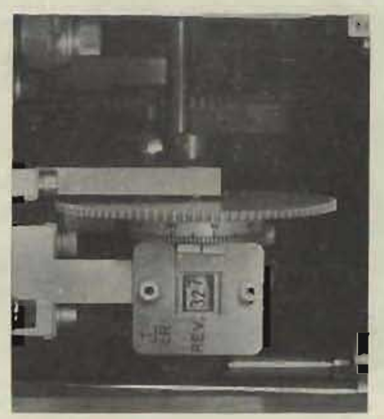
PART OF RECORD FORM PROVIDED IN NAVORD 1229

TROUBLE ANALYSIS TESTS — INTEGRATOR TIMING

T/cR INTEGRATOR TEST							
CALC.		14.99	19.98	29.97	39.96	59.94	199.81
RANGE		20000	15000	10000	7500	5000	1500
DATE	CK. BY	R.P.M. OF T/cR COUNTER					
		15.03					

CALCULATED NUMBER OF REVOLUTIONS

RECORD HERE THE DIFFERENCE BETWEEN THE INITIAL READING AND THE READING AFTER ONE MINUTE



T/cR COUNTER READS 327.37 AFTER ONE MINUTE

1 Remove cover 3.

2 Turn the power ON.

3 Turn the control switch to SEMI-AUTO.

4 Disconnect the range integrator or establish a zero range rate. (For this procedure, refer to *B Tests*, page 33.)

5 Tighten A-141 with the gear in mesh.

6 Set *cR* at 20,000 yards.

7 With the time crank in the OUT position, turn the time line until the index on the half-second dial lines up exactly with the fixed index.

8 With the time crank in the IN position, turn the time line until the seconds dial reads 0 against the fixed index.

9 Read the value on the *T/cR* counter.

10 Turn the time crank in the OUT position to increase the speed on the time line *gradually*. Then turn the time motor ON.

11 Allow the time line to turn until the seconds dial reads approximately 55 sec. Then turn the time motor OFF.

12 Turn the time crank in the OUT position, until the seconds dials reads 0 and the index on the half-second dial is lined up *exactly* with the fixed index.

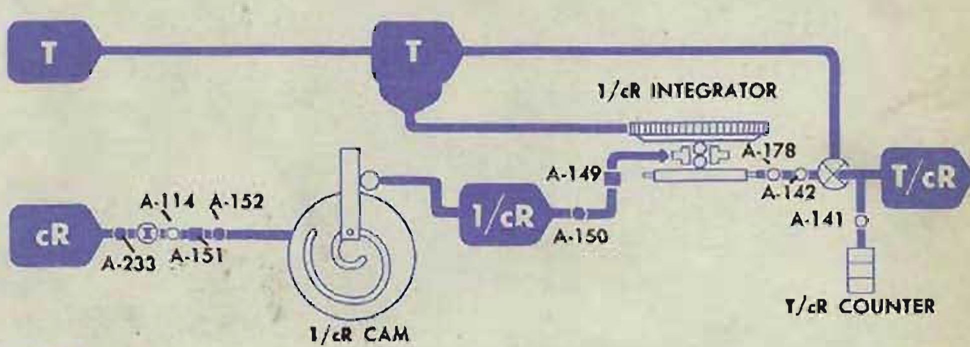
13 Read the *T/cR* counter. Compute and record the difference between the initial and the present reading.

For example: Suppose that the *T/cR* counter reads 312.34 when the seconds dial reads 0 before the time line is turned, and that after one minute, the *T/cR* counter reads 327.37. The difference between these two counter readings is 327.37 – 312.34, or 15.03. This indicates that the *T/cR* counter has made 15.03 revolutions for one revolution of the time-seconds dial. Record the number of revolutions in the space provided.

14 Complete the *T/cR* integrator check test in the same manner with *cR* at 15,000 yards, 10,000 yards, etc.

15 Compute the errors by subtracting the calculated values from the recorded values. For example: Suppose a reading of 15.03 is recorded in the 20,000-yards range test for which the calculated value is 14.99. The error is 15.03 − 14.99, or +0.04.

THE T/cR INTEGRATOR NETWORK



Correcting the errors

Before correcting any errors, compare them with previous values from tests run after satisfactory B test results were obtained. Reduce the errors to these previously recorded values. If no records are available, reduce the errors to an average near +0.05. In either case, reduce the errors by following the procedure given below.

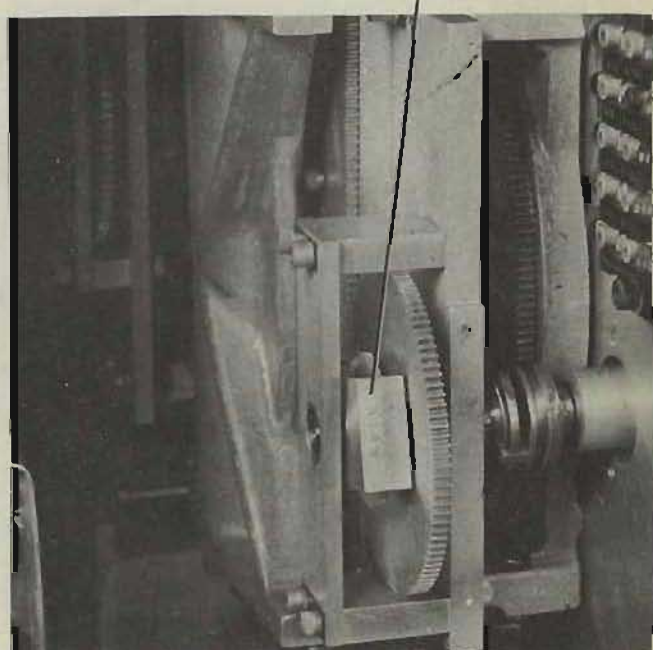
If there are errors of several complete revolutions of the *T/cR* counter, check for mechanical trouble. Check the *cR* line, the 1/*cR* cam, and the 1/*cR* integrator. Refer to *Locating Casualties* and to OP 1140A. If these units have been removed and reinstalled, tighten A-114 and readjust A-233, A-151, and A-150. If there is no A-150 on the instrument, readjust at the gear mesh.

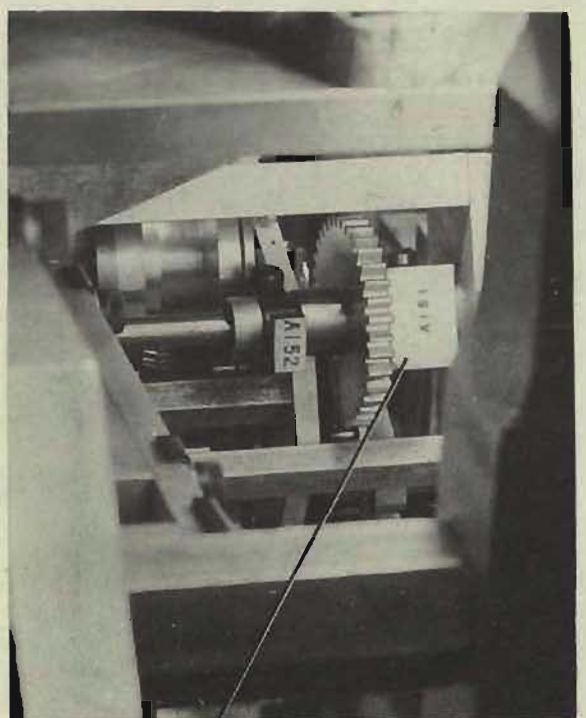
Repeat the *T/cR* integrator check test.

If the readings differ from the desired values by relatively small amounts, refine the vernier adjustments A-149 and A-151 as follows:

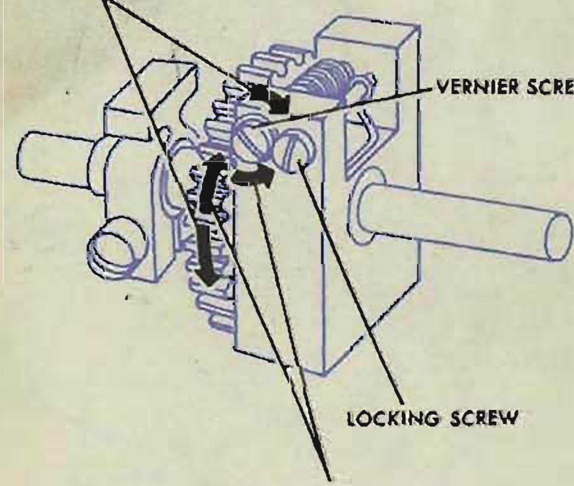
1 Loosen the locking screw on A-149. Turn the vernier screw counterclockwise to increase the integrator output, i.e., to correct a negative error. Turn the vernier screw clockwise to decrease the integrator output, i.e., to correct a positive error. Tighten the locking screw.

VERNIER ADJUSTMENT A-149 (UNDER COVER 5)





VERNIER ADJUSTMENT
A-151 (UNDER COVER 5)



2 Set cR at 20,000 yards. Run the T/cR check test at this range only, and refine A-149 until the desired test value is obtained.

3 Set cR exactly at 1500 yards. Run the T/cR check test at this range only.

4 Loosen the locking screw on A-151. Turn the vernier screw counterclockwise to increase the integrator output, i.e., to correct a negative error. Turn the vernier screw clockwise to decrease the integrator output, i.e., to correct a positive error. Tighten the locking screw.

5 Again run the T/cR check test with cR set exactly at 1500 yards. Refine A-151 until the desired test value is obtained.

6 Repeat the full T/cR integrator check test.

If the results are still unsatisfactory, further refine A-149 and A-151. If the results tend to be unstable at a fixed value of range, refer to *Disk Integrators,* OP 1140A.

After the check test is completed:

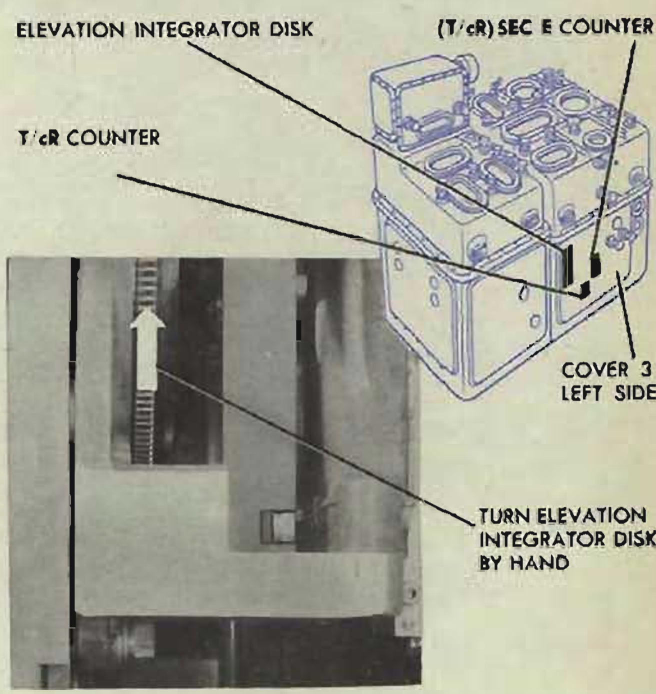
1 Reconnect the range integrator if it was disconnected.

2 Disconnect the T/cR counter if there is a sliding gear for the purpose (on later instruments only). To do this, loosen A-141, unmesh the gear, and tighten A-141.

3 Replace cover 3.

(T/cR) sec E INTEGRATOR CHECK TEST

1 Turn the power ON.



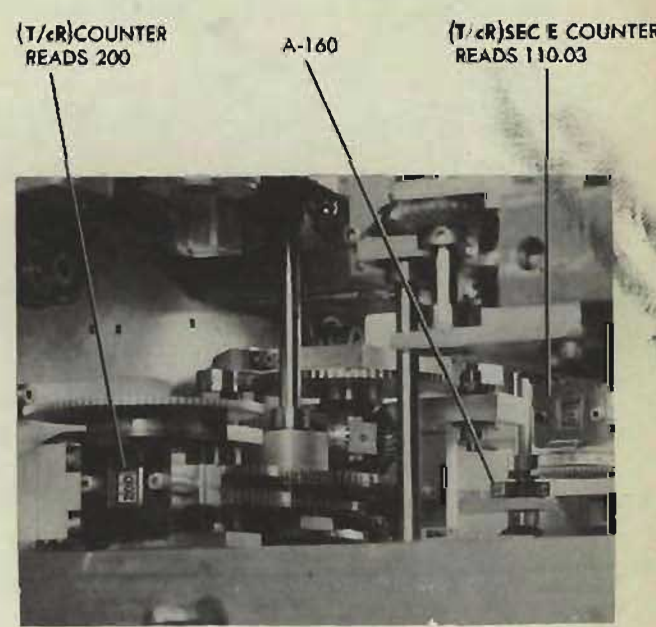
2 Turn the control switch to SEMI-AUTO.

3 Disconnect the range integrator, or establish a zero range rate. (For this procedure, refer to *B Tests*, page 33.)

4 Remove cover 3. Tighten A-160 and A-141 with the gears in mesh.

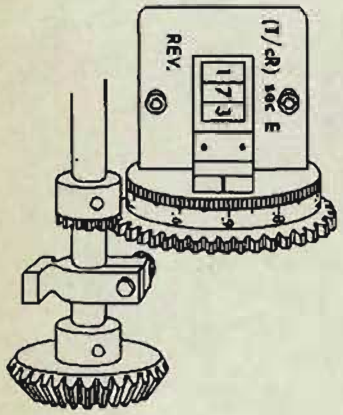
5 Set *cR* at 1500 yards.

6 Set *E* at 0°.
Turn the disk of the elevation integrator by hand until the *T/cR* counter reads a whole hundred.



7 Read the (*T/cR*) sec *E* counter.

8 Turn the time motor ON. When the *T/cR* counter has made approximately 90 revolutions, turn the time motor OFF. Turn the disk of the elevation integrator by hand, until the *T/cR* counter has made *exactly 100 revolutions* from the original value.



(T/cR) SEC E COUNTER READS 172.91

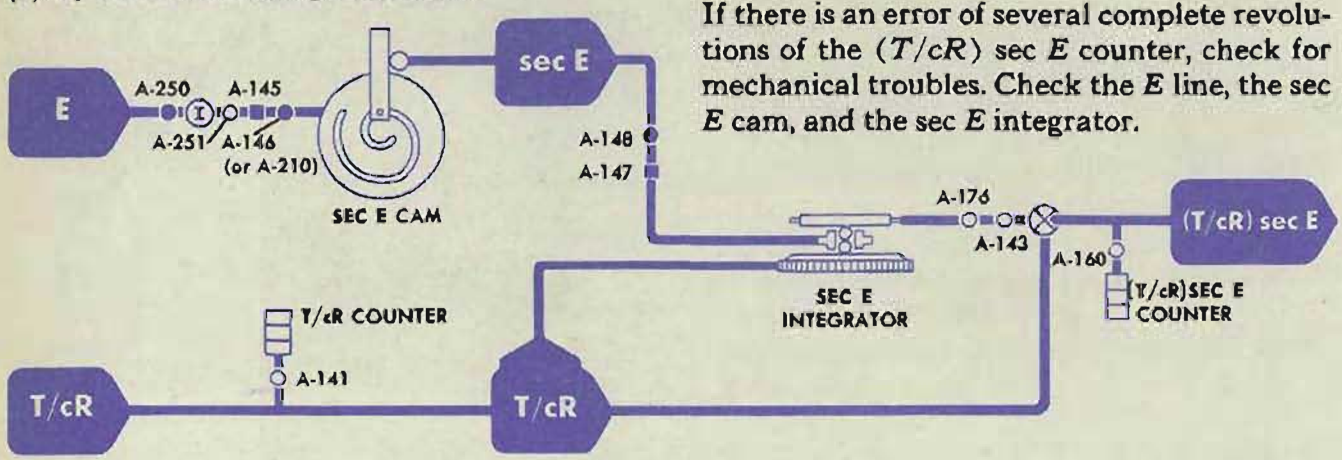
PART OF RECORD FORM PROVIDED IN NAVORD FORM 1229

TROUBLE ANALYSIS TESTS — INTEGRATOR TIMING

T/cR SEC E INTEGRATOR TEST							
CALC.		62.84	66.87	82.03	97.74	125.66	183.73
E		0°	20°	40°	50°	60°	70°
DATE	CK BY	REVOLUTIONS OF T/cR SEC E COUNTER PER 100 REVOLUTIONS OF T/cR COUNTER					
		62.88					

RECORD HERE THE DIFFERENCE BETWEEN THE INITIAL READING OF (T/cR) SEC E AND THE READING AFTER 100 REVOLUTIONS OF T/cR.

(T/cR) SEC E INTEGRATOR NETWORK



9 Read the (T/cR) sec E counter. Compute and record the difference between the initial and the present (T/cR) sec E counter reading.
For example: Suppose that the (T/cR) sec E counter reads 110.03 when the T/cR counter reads 200.00 and that after 100 revolutions of the T/cR counter the (T/cR) sec E counter reads 172.91. The difference between the two readings, therefore, is 172.91 −110.03, or 62.88. This indicates that the (T/cR) sec E counter has made 62.88 revolutions for 100 revolutions of the T/cR counter.

10 Complete the (T/cR) sec E integrator check test in the same manner with E at 20°, 40°, etc., as indicated on the test form.

11 Compute the errors by subtracting the calculated values from the recorded values.
For example: Suppose that a reading of 62.88 is recorded in the 0° elevation test for which the calculated value is 62.84. The error is 62.88 −62.84, or +0.04.

Correcting the errors

Before correcting any errors, compare them with previous values from tests run after satisfactory B test results were obtained. Reduce the errors to these previously recorded values. If no records are available, reduce the errors to an average near +0.05. In either case, reduce the errors by following the procedure given below.

If there is an error of several complete revolutions of the (T/cR) sec E counter, check for mechanical troubles. Check the E line, the sec E cam, and the sec E integrator.

If these units have been removed and reinstalled, tighten A-251 and readjust A-250, A-146 (or A-210), and A-148. If there is no A-148 on the instrument, readjust at the gear mesh.

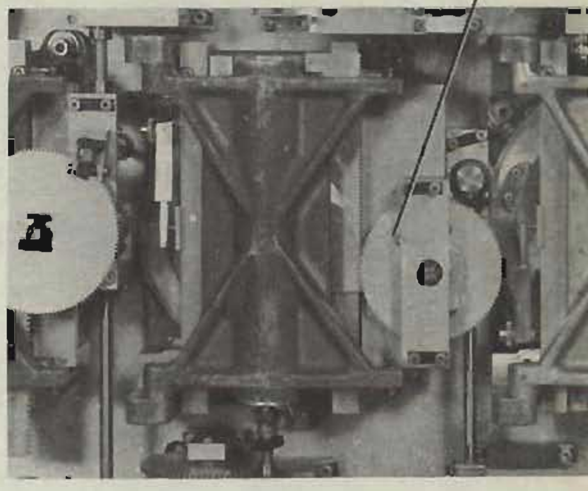
If the readings differ from the desired values by relatively small amounts, refine the vernier adjustments A-147 and A-145 as follows:

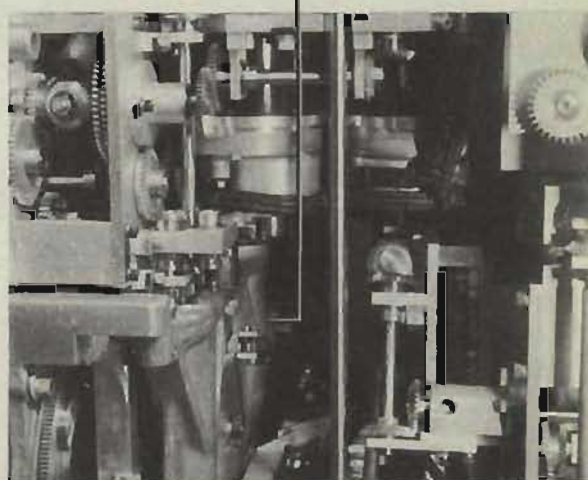
1. Loosen the locking screw on A-147. Turn the vernier screw counterclockwise to increase the integrator output, i.e., to correct a negative error.
   Turn the vernier screw clockwise to decrease the output, i.e., to correct a positive error. Tighten the locking screw.
2. Set E at 0°.
   Run the (T/cR) sec E check test at this elevation only, and refine A-147 until the desired test value is obtained.
3. Set E exactly at 70°.
   Run the (T/cR) sec E check test at this elevation only.
4. Loosen the locking screw on A-145. Turn the vernier screw counterclockwise to increase the integrator output, i.e., to correct a negative error. Turn the vernier screw clockwise to decrease the integrator output, i.e., to correct a positive error.
   Tighten the locking screw.
5. Again run the (T/cR) sec E check test with E set exactly at 70°. Refine A-145 until the desired test value is obtained.
6. Repeat the full (T/cR) sec E check test.

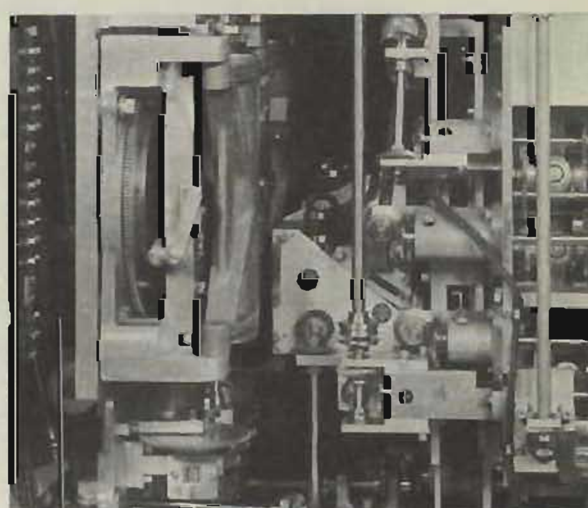
If the results are still unsatisfactory, further refine A-147 and A-145. If the results tend to be unstable at a fixed value of elevation, refer to *Disk Integrators*, OP 1140A.

After the check test is completed:

1. Reconnect the range integrator, if it was disconnected.
2. Disconnect the T/cR and (T/cR) sec E counters if sliding gears are provided for the purpose (on later instruments only). To do this, loosen A-141 and A-160, unmesh the respective gears and tighten A-141 and A-160.
3. Replace cover 3.







PARALLAX CHECK TEST

This parallax check test is arranged for use with instruments in which gun train order, *B'gr*, drives the parallax component solver.

If director train, *B'r*, drives the parallax component solver, the same check test may be used by substituting *B'r* for all readings of *B'gr*. To do this, hold *Dd* at 0 and read *B'r* on the *B'gr* dial. Refer to the adjustment of A-242, page 461.

Check the Ph Dial

1. Turn the power switch ON.
2. Set *B'gr* and *E2* at 0.
3. Set *L* at 2000'.
4. Set *R2* at 18000 yards.

The *Ph* dial should read 0. If it does not, check A-517 and A-52.

Check the vector gear of the Parallax Component Solver

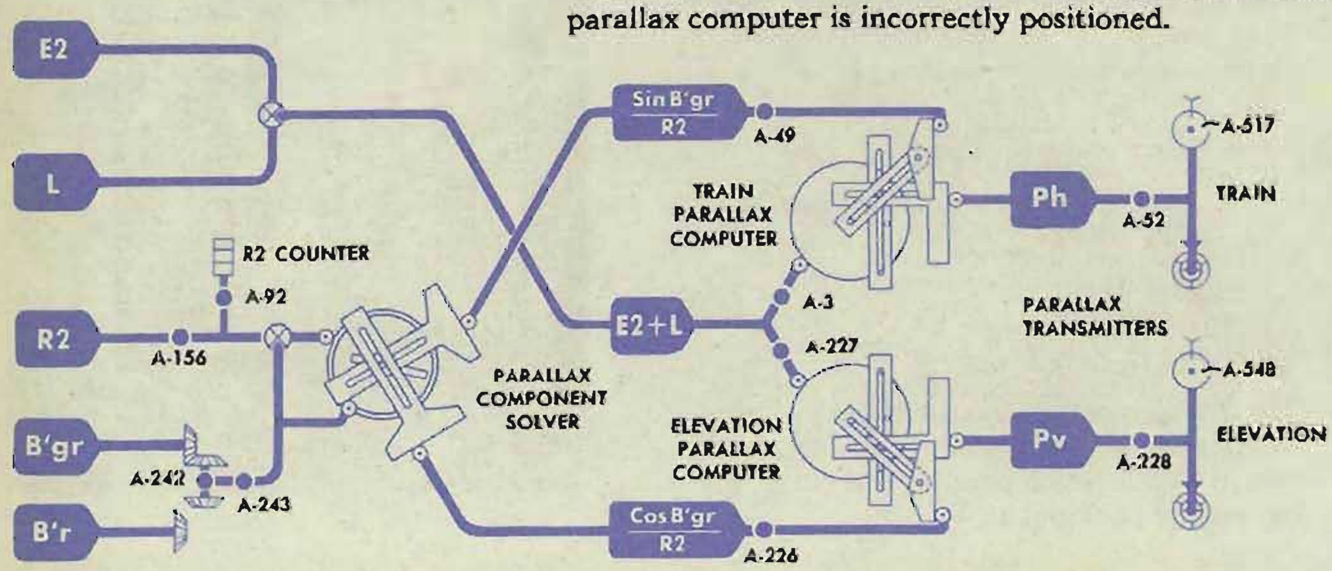
1. Check that *L* is at 2000' and *B'gr* is at 0.
2. Set *E2* at 70°.
3. Turn *R2* from 18000 yards to 500 yards.

The *Ph* dial should remain at a fixed value during full travel of *R2*. If it does not, the vector gear of the parallax component solver is incorrectly positioned.

Check the input rack of the Train Parallax Computer

1. Check that *L* is at 2000' and *B'gr* is at 0.
2. Set *R2* at 18000 yards.
3. Turn *E2* from 0 to 90°.

The *Ph* dial should remain at a fixed value during full travel of *E2*. If it does not, the input rack of the train parallax computer is incorrectly positioned.



Check the cam of the Parallax Component Solver

1 Check that L is at 2000′.
2 Set $B'gr$ and $E2$ at 90°.
3 Set $R2$ at 1560 yards.

The Ph dial should read RIGHT 10°59′. If it does not, the cam of the parallax component solver is incorrectly positioned.

Check the cam of the Train Parallax Computer

1 Check that L is at 2000′, $R2$ is at 1560 yards, and $B'gr$ is at 90°.
2 Set $E2$ at 60°.

The Ph dial should read RIGHT 7°20′. If it does not, the cam of the train parallax computer is incorrectly positioned.

Check the Pv Dial

1 Check that L is at 2000′ and $B'gr$ is at 90°.
2 Set $R2$ at 18000 yards.
3 Set $E2$ at 0.

The Pv dial should read 0. If it does not check A-548 and A-228.

Check the input rack of the Elevation Parallax Computer

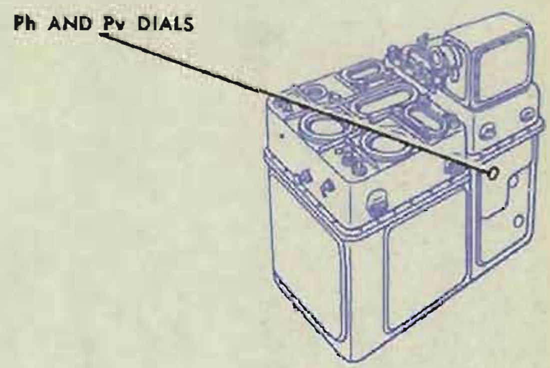
1 Check that L is at 2000′, $B'gr$ is at 90°, and $R2$ is at 18000 yards.
2 Turn $E2$ from 0 to 90°.

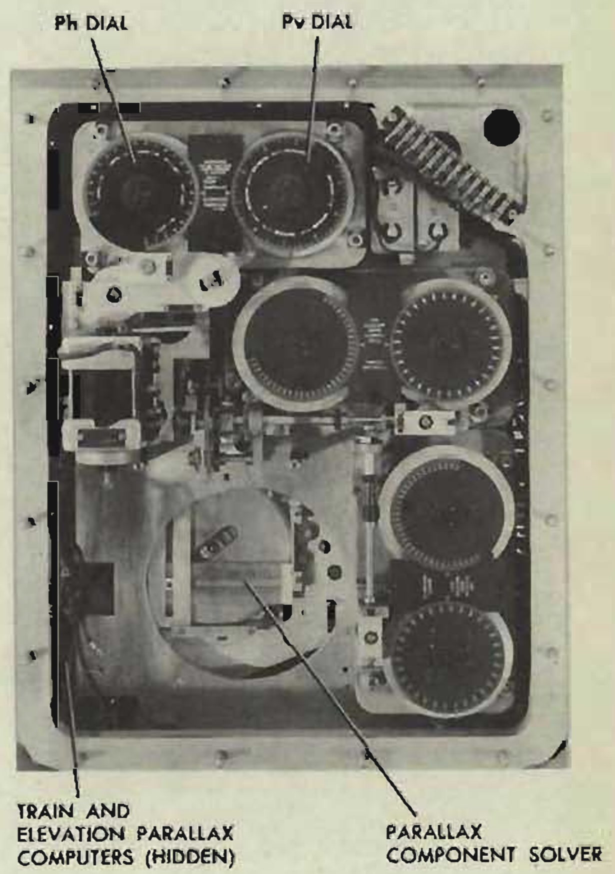
The Pv dial should remain at a fixed value during full travel of $E2$. If it does not, the input rack of the elevation parallax computer is incorrectly positioned.

Check the cam of the Elevation Parallax Computer

1 Check that L is at 2000′.
2 Set $E2$ at 0°.
3 Set $R2$ at 1500 yards.
4 Turn $B'gr$ from 90° to 0°

The Pv dial should remain at a fixed value during the travel of $B'gr$. If it does not, the cam of the elevation parallax computer is incorrectly positioned.



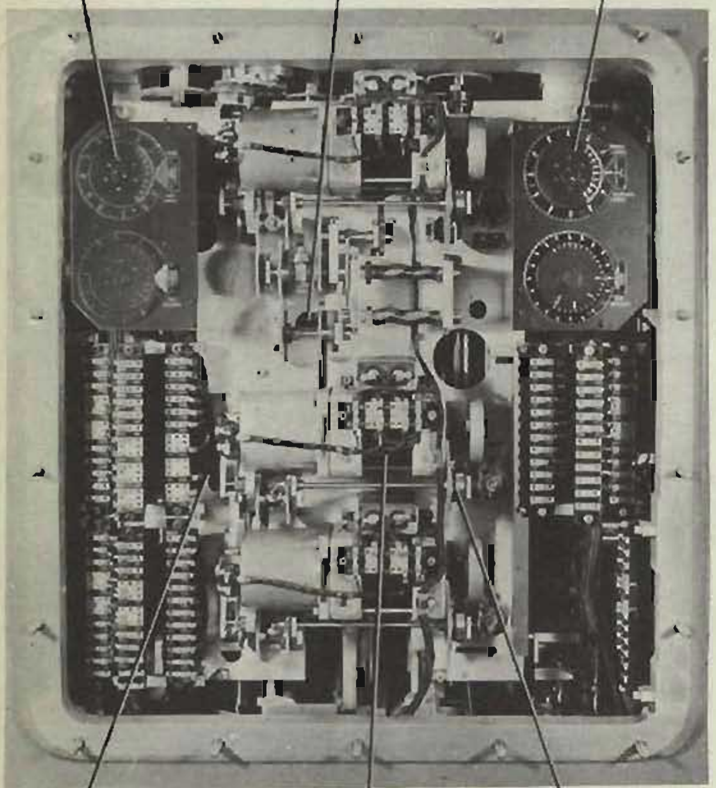


CONTENTS

VOLUME ONE

VOLUME TWO

DECK TILT CHECK TEST



Preliminary setup

1 Turn the power switch ON.
2 Turn the control switch to SEMI-AUTO.

Check the synchronization of the jB'r Follow-up

1 Set *L* and *Zd* at 2000′.
2 Set *B′r* at 0°00′, on the stable element dials.

The *Br* ring dials should read 0°00′.
If *Br* does not read 0°00′, check the *jB′r* follow-up and the connecting shaft lines.

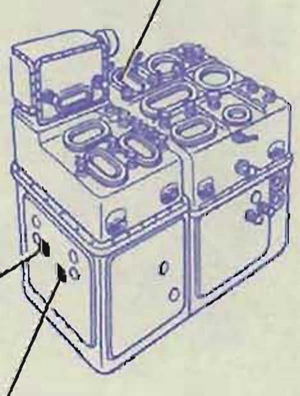
Check the Deck Tilt Component Solver

1 Set *B′r* at 45°.
2 Observe clamp A-64 while turning *L* from 500′ to 3500′.

If movement of A-64 is observed, the vector gear of the deck tilt component solver is incorrectly positioned.

1 Set *L* at 2000′.
2 Observe A-64 while turning *B′r* from 0° to 180°.

If movement of A-64 is observed, the *L* cam of the deck tilt component solver is incorrectly positioned.



Check the Zd (L−L cos 2B′r) Multiplier

1 Check that *L* is at 2000′.
2 Set *B′r* at 0°.
3 Observe the *jB′r* follow-up output gearing for motion while turning *Zd* from 500′ to 3500′.

If motion is observed, the input rack of the *Zd* $(L - L \cos 2B'r)$ multiplier is incorrectly positioned.

1 Set *Zd* at 2000′.
2 Set *B′r* at 90°.
3 Observe the *jB′r* follow-up output gearing while turning *L* from 500′ to 3500′.

If there is motion at the *j′Br* follow-up output gearing, observe A-62, and again turn *L* from 500′ to 3500′.

If there is motion of A-62, the input rack of the *L* (*L* sin *2B′r*) multiplier is incorrectly positioned.

If A-62 is stationary, but there is motion at the *jB′r* follow-up output gearing, the lead screw of the *Zd* (*L* —*L* cos *2B′r*) multiplier is incorrectly positioned.

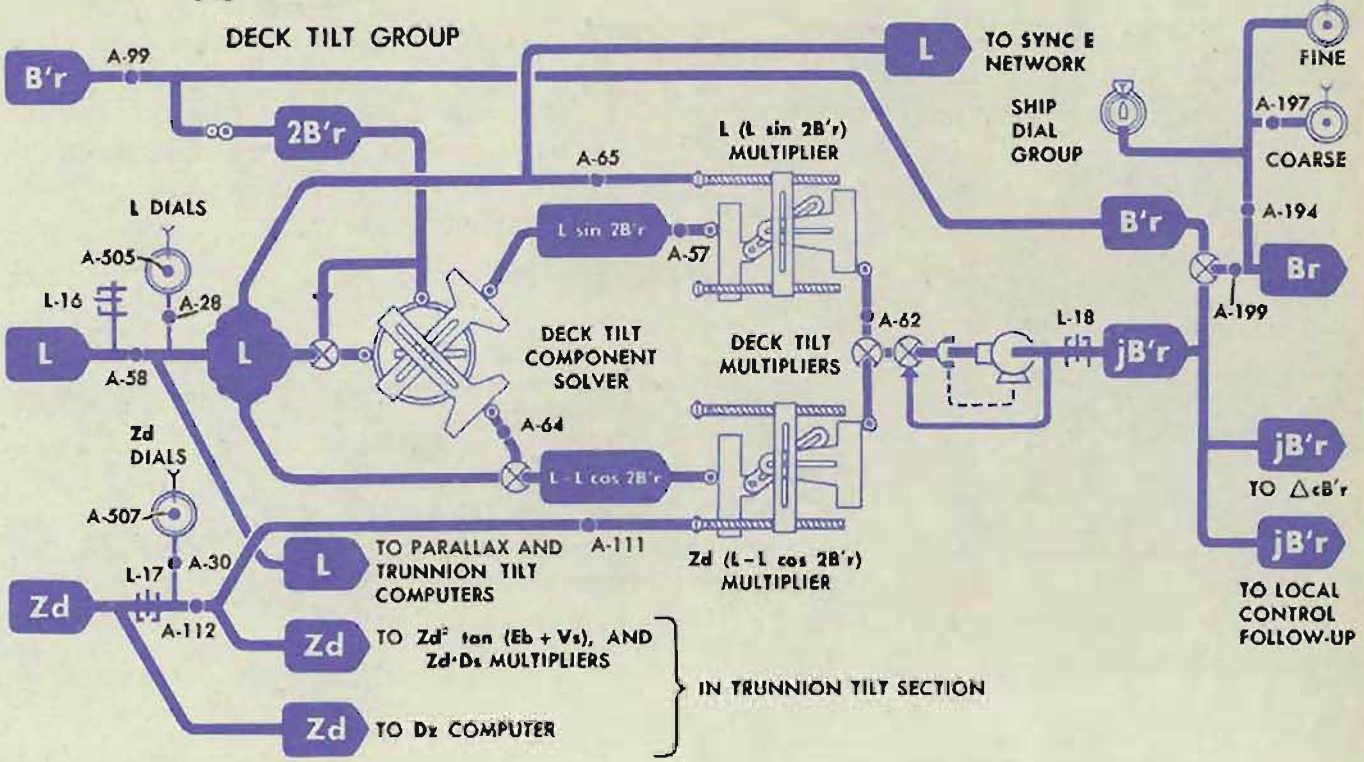
Check the L (L sin 2B′r) Multiplier

1 Set *Zd* at 2000′.
2 Set *B′r* at 0°.
3 Turn *L* from 500′ to 3500′ and observe the *jB′r* follow-up.

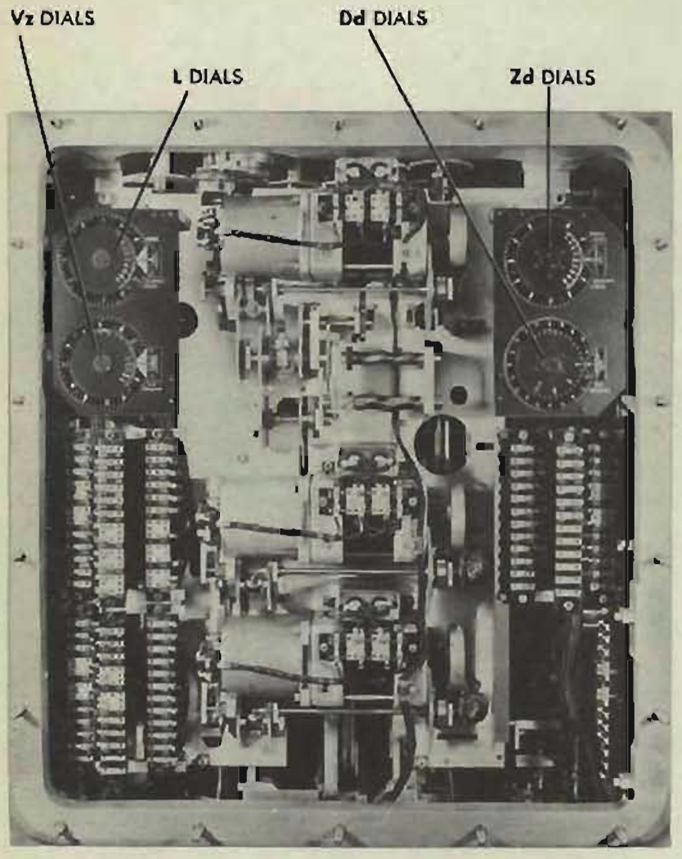
If there is motion of the *jB′r* follow-up output gearing, the *L* sin *2B′r* input rack of the *L* (*L* sin *2B′r*) multiplier is incorrectly positioned.

1 Set *Zd* at 2000′.
2 Set *B′r* at 45°.
3 Turn *L* to 3200′.
4 The *Br* ring dials should read 46°21′. Record the error.
5 Turn *L* to 800′.
6 The *Br* ring dials should read 46°21′. Record the error.

If the *Br* ring dials do not read 46°21′ for both values of *L*, the lead screw of the *L* (*L* sin *2B′r*) multiplier is incorrectly positioned.

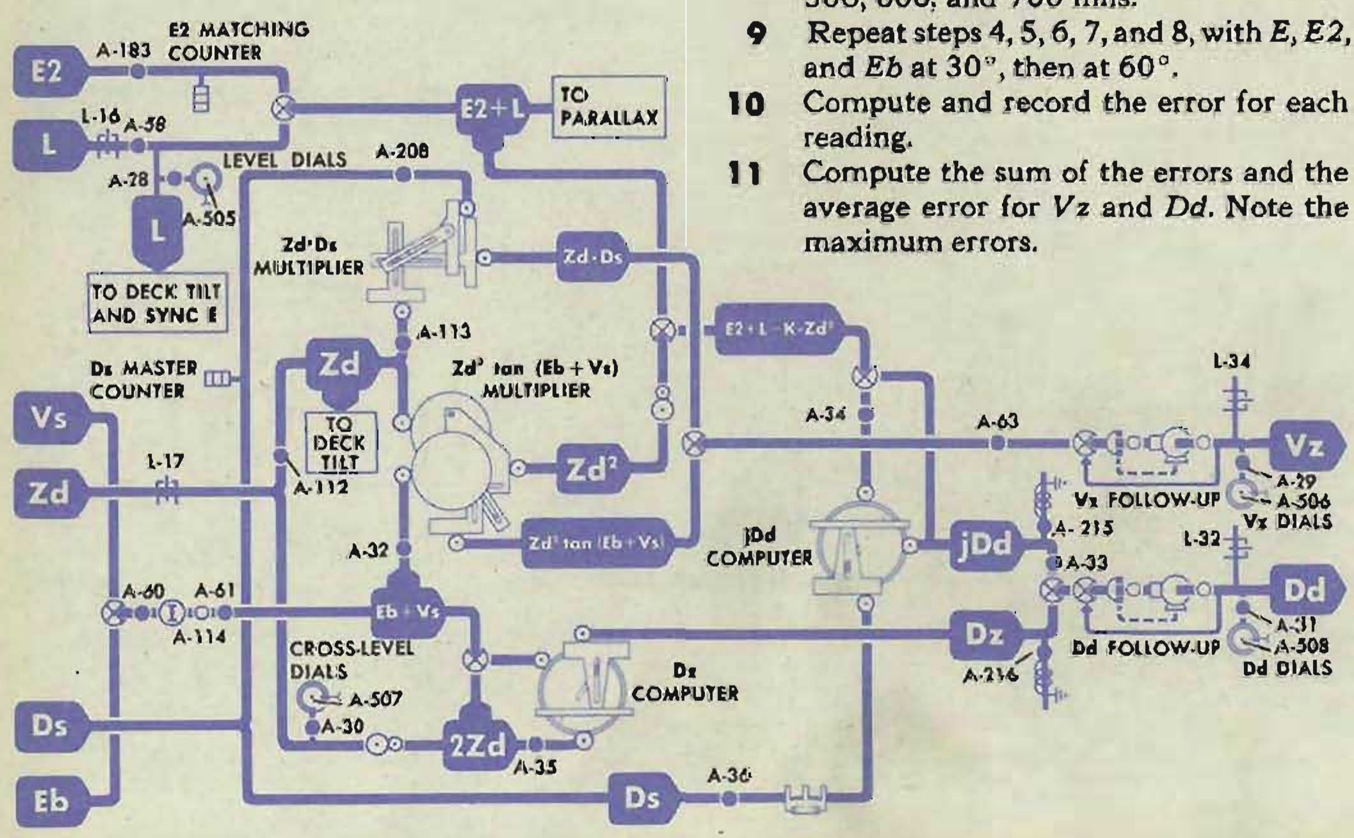


TRUNNION TILT CHECK TEST



Making the test

1. Set *L* and *Vs* at 2000′.
2. Match *E* and *E2* as follows:
   Remove power leads C1 and CC from the *Vf* + *Pe* follow-up. Set *Vf* + *Pe* at 0 and wedge the follow-up output gearing. Set *I.V.* at 2550 f.s. *E2* will then remain equal to *E* for all settings of *E*.
3. Set *E* at 0° with sync *E* handcrank at CENTER. (*E2* will also be zero.)
   Match the sync *E* dials at the fixed index with the sync *E* handcrank OUT. (*Eb* will then equal *E* since *L* equals 2000′.)
4. Set *Ds* at 300 mils.
5. Set *Zd* at 3200′ in an increasing direction.
   Read and record the values of *Vz* and *Dd*.
6. Set *Zd* at 3200′ in a decreasing direction.
   Read and record the values of *Vz* and *Dd*.
7. Continue the test in the same manner, setting *Zd* at 2600′, 2000′, 1400′ and 800′.
8. Repeat steps 5, 6, and 7, with *Ds* at 400, 500, 600, and 700 mils.
9. Repeat steps 4, 5, 6, 7, and 8, with *E*, *E2*, and *Eb* at 30°, then at 60°.
10. Compute and record the error for each reading.
11. Compute the sum of the errors and the average error for *Vz* and *Dd*. Note the maximum errors.



The necessary record forms for the Trunnion Tilt Test are provided in NAVORD Form 1229. Samples of these sheets are shown below.

TROUBLE ANALYSIS TESTS — **TRUNNION TILT CORRECTOR TEST**

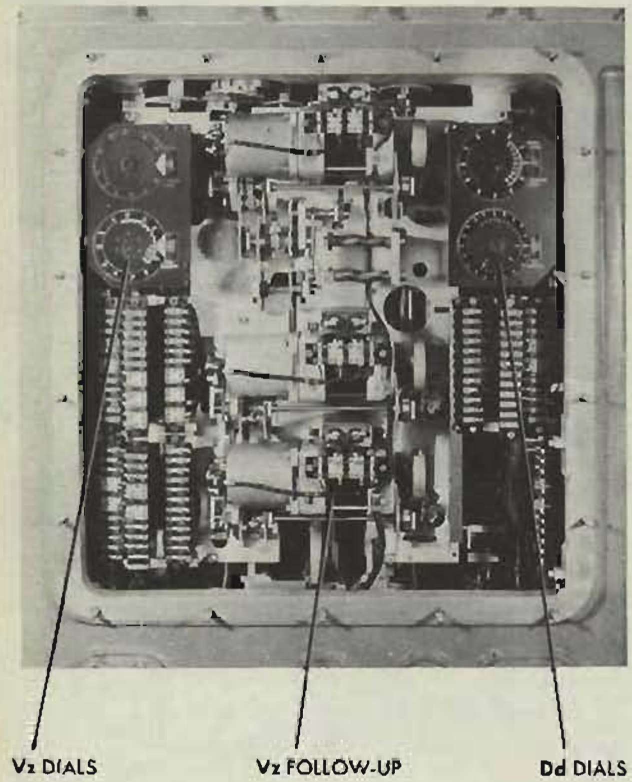
READ Vz

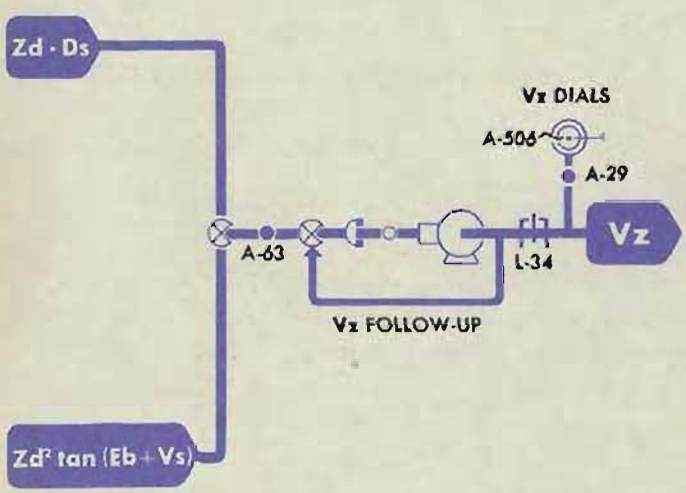
Zd		3200			2600			2000			1400			800		
Ds	Zd	CALC	READ	ERR	CALC	READ	ERR	CALC	READ	ERR	CALC	READ	ERR	CALC	READ	ERR
E AND E2 AT 0°																
300	INC	-276			-138			0			+138			+276		
	DEC															
400	INC	-138			-69			0			+69			+138		
	DEC															
500	INC	0			0			0			0			0		
	DEC															
600	INC	+138			+69			0			-69			-138		
	DEC															
700	INC	+276			+138			0			-138			-276		
	DEC															
E AND E2 AT 30°																
300	INC	-171			-112			0			+164			+381		
	DEC															

TROUBLE ANALYSIS TESTS — **TRUNNION TILT CORRECTOR TEST**

READ Dd

Zd		3200			2600			2000			1400			800		
Ds	Zd	CALC	READ	ERR	CALC	READ	ERR	CALC	READ	ERR	CALC	READ	ERR	CALC	READ	ERR
E AND E2 AT 0°																
300	INC	-11°			-11°			-11°			-11°			-11°		
	DEC	32'			32'			32'			32'			32'		
400	INC	-5°			-5°			-5°			-5°			-5°		
	DEC	44'			44'			44'			44'			44'		
500	INC	0°			0°			0°			0°			0°		
	DEC	00'			00'			00'			00'			00'		
600	INC	+5°			+5°			+5°			+5°			+5°		
	DEC	44'			44'			44'			44'			44'		
700	INC	+11°			+11°			+11°			+11°			+11°		
	DEC	32'			32'			32'			32'			32'		
E AND E2 AT 30°																
300	INC	-1°			-7°			-13°			-18°			-23°		
	DEC	03'			04'			21'			55'			19'		





Locating errors

If the errors in both *Dd* and *Vz* are excessive, *Vz* should be checked first.

NOTE:
See page 222 for instructions on setting *E2* and *Eb*.

Checking Vz

Check the Vz Follow-up

1 Set *Ds* at 500 mils.
2 Set *L*, *Zd*, and *Vs* at 2000′.
3 Set *Eb* at 0°.

The *Vz* dial should read 00′.
If the *Vz* dial does not read 00′, check the *Vz* follow-up and A-63.

Check the Zd rack of the Zd · Ds Multiplier

1 Set *Zd* at 2000′.
2 Set *Ds* at 100 mils.
3 Turn *Ds* from 100 mils to 900 mils.

There should be no movement of the *Vz* dial while *Ds* is run from 100 to 900 mils. If the *Vz* dial moves, the *Zd* input rack is incorrectly positioned.

Check the Ds rack of the Zd · Ds Multiplier

1 Check A-114 and A-61 for tightness.
Check the cut-out points of the *Eb* + *Vs* intermittent drive (A-60).
Set *Eb* at 0.
Set *Vs* at 1500′.
2 Set *Ds* at 500 mils.
3 Turn *Zd* from 800′ to 3200′ and observe the *Vz* dials for motion.

If there is any motion of the *Vz* dials the *Ds* rack of the *Zd·Ds* multiplier is incorrectly positioned.

Check the Zd^2 tan (Eb + Vs) Multiplier

1 Set *Ds* at 500 mils.
2 Set *Vs* at 2000′.
3 Set *L* at 2000′.
4 Set *Eb* at 60°.
5 Set *Zd* at 800′.

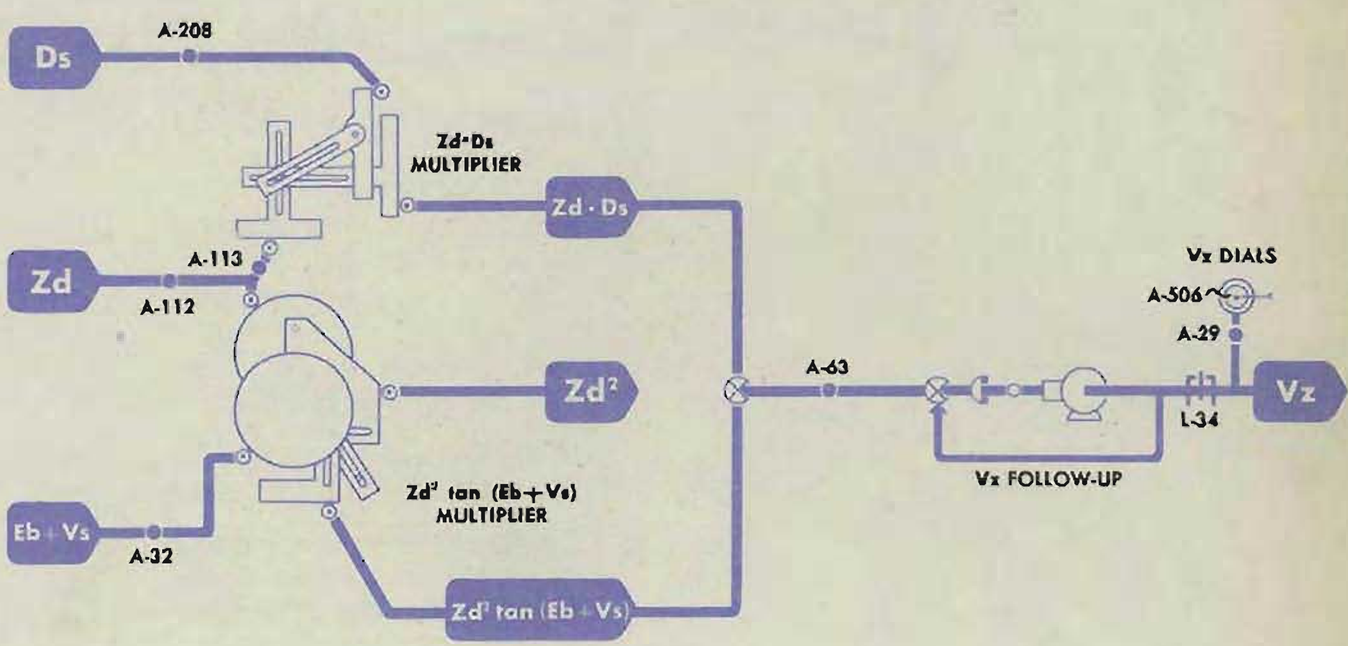
The *Vz* dial should read +316′. Record the reading.

6 Turn *Zd* from 800′ to 3200′.

The *Vz* dial should again read +316′. Record the reading.

If the *Vz* dial readings are not equal, the square cam of the Zd^2 tan $(Eb + Vs)$ multiplier is incorrectly positioned.

If the *Vz* dial readings are equal, but greater or less than +316′, the $Eb + Vs$ cam of the Zd^2 tan $(Eb + Vs)$ multiplier is incorrectly positioned.



Checking Dd

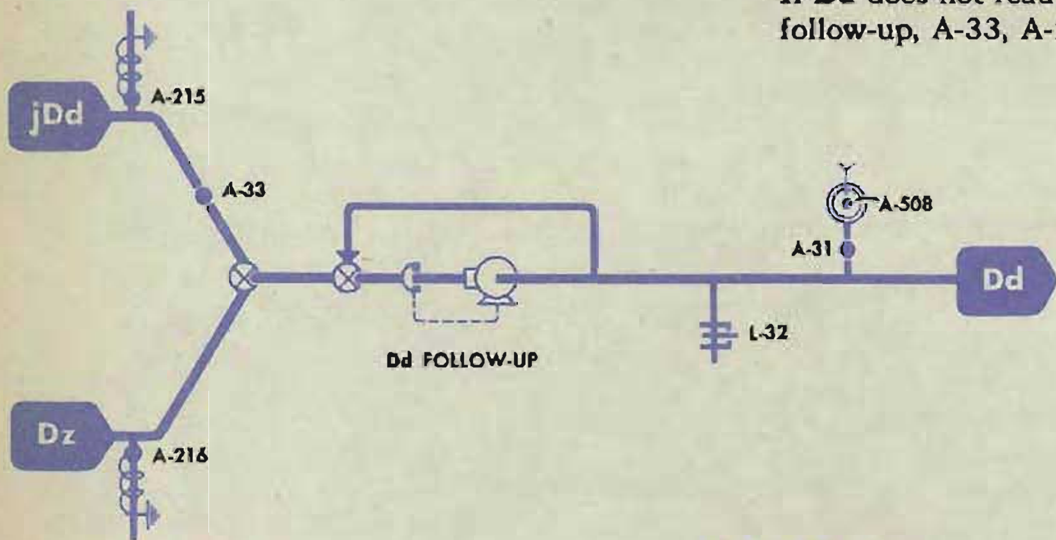
Check the Dd Follow-up

1 Set *Ds* at 500 mils.
2 Set *Zd, L,* and *Vs* at 2000′.
3 Set *E2* at 0°.
4 Set *Eb* at 0°.

NOTE:
See page 222 for instructions on setting *E2* and *Eb*.

The *Dd* dials should read 0°00′.

If *Dd* does not read 0°00′, check the *Dd* follow-up, A-33, A-215 and A-216.



Check the jDd Computer Rack and the Dz Computer Vector Gear

1 Set *Ds* at 500 mils.
2 Set *Zd, L,* and *Vs* at 2000′.
3 Set *Eb* and *E2* at 0°.
4 The *Dd* dials should read 0.
5 Put the sync *E* handcrank at CENTER and increase *E* from 0° to 60°.
The *Dd* dials should not move.

If the *Dd* dials move, the *Ds* rack of the *jDd* computer is incorrectly positioned.

6 Pull the sync *E* handcrank OUT and rematch the sync *E* dials at the fixed index.
The *Dd* dials should not move.

If the *Dd* dials move, the vector gear of the *Dz* computer is incorrectly positioned.

Check the cam of the Dz Computer

1. Set *Ds* at 500 mils.
2. Set *E2* at 0°.
3. Set *L* and *Vs* at 2000′.
4. Set *Eb* at 60°.
5. Check that *E2* has remained at 0°.
6. Set *Zd* at 800′.
   The *Dd* dial should read −30°34′. Compute the error.
7. Set *Zd* at 3200′.
   The *Dd* dial should read +30°34′. Compute the error.

Compare the two errors. They should be of like sign and equal magnitude. For example: Readings of −30°31′ and +30°37′ would be satisfactory (error equals +3′ in each case).

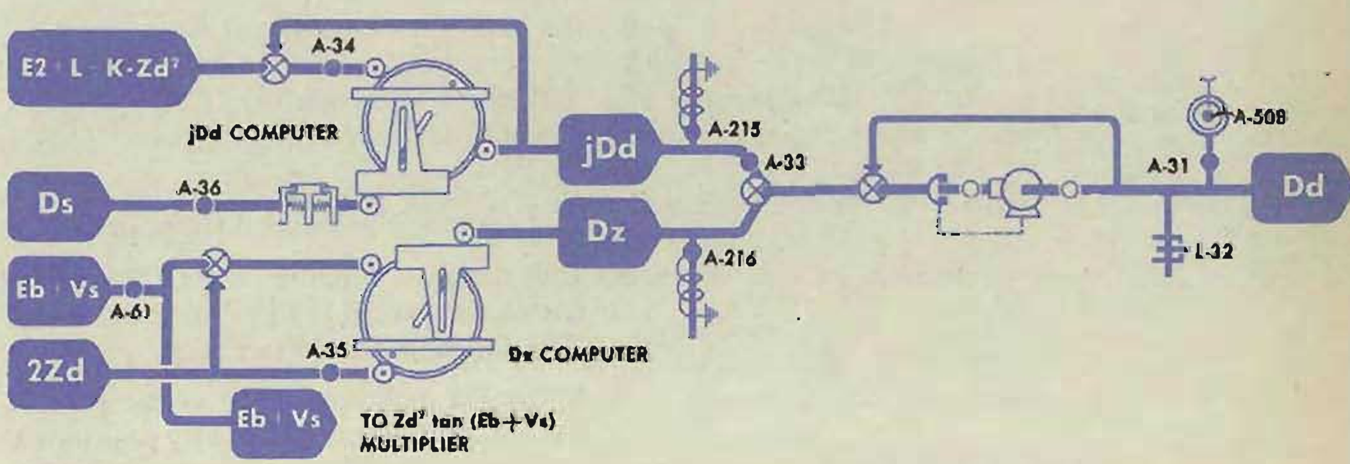
If the errors are unequal or of unlike sign, the *Eb* + *Vs* cam of the *Dz* computer is incorrectly positioned.

Check the cam of the jDd Computer

1. Check that *L* and *Vs* are at 2000′.
2. Set *Zd* at 2000′.
3. Set *E2* at 60°.
4. Set *Eb* at 0°.
5. Check that *E2* still equals 60°.
6. Set *Ds* at 300 mils.
   The *Dd* dial should read −23°35′. Compute the error.
7. Set *Ds* at 700 mils.
   The *Dd* dial should read +23°35′. Compute the error.

Compare the two errors. They should be of like sign and equal magnitude. For example: Readings of −23°32′ and +23°38′ would be satisfactory (error equals +3′ in each case).

If the errors are unequal or of unlike sign, the $E2 + L - K \cdot Zd^2$ cam of the *jDd* computer is incorrectly positioned.



SUMMARY of UNIT CHECK TESTS

Deflection prediction multiplier

A-102 All inputs at zero. *Vf* + *Pe* at 100 (010 on counter).
Range below 500.
Ds should read 500.

A-131 Run range above 18,000.
Ds should not change.

A-133 Adjust range to set *Tf*/*R2* at 0.00225. Set *Sh* at 300.
Set *A* at 90. *Ds* should read 885.
Set *A* at 270. *Ds* should read 115.

Elevation prediction multiplier

A-103 *A*, *Br*, and *Bws* at 90. All other inputs at zero.
Vf + *Pe* at 0. Range below 500.
Vs should read 2000.

A-134 Run range above 18,000.
Vs should not change.

A-79 Adjust range to set *Tf*/*R2* at 0.00215.
Set *dH* at +100. *Vs* should read 2418.6.
Set *dH* at −100. *Vs* should read 1581.4.

Range prediction multiplier

A-104 *A*, *Br*, and *Bws* at 90. All other inputs at zero.
Adjust range to set *Tf* at 5.00 (050 on counter).
Adjust *E* to set *E2* about 79.
R2 should equal *cR*.

A-135 Run range to slightly under 18,000.
R2 should follow, equalling *cR* at all values.

A-81 Wedge *Tf* at 40.00. Set *cR* at 10,000, *E* at 0, and *Sh* at 300.
Set *A* at 0. *R2* should read 3244.
Set *A* at 180. *R2* should read 16756.

Dead time prediction multiplier
Ser. Nos. 780 and lower

A-203 *Tg* and *dR* at zero.
R3 should equal *R2*.
A-132 *dR* at zero. Run *Tg* to 6.
R3 should not change.
A-188 *Tg* at zero. Run *dR* ±450.
R3 should equal *R2*.

Dead time prediction multiplier
Ser. Nos. 781 and higher

A-203 All inputs at zero. Set *F* to equal *Tf*.
R3 should equal *R2*.
A-132 Run *F* between limits.
R3 should not change.
A-188 *F* equal to *Tf*. Run *dR* from −450 to +450.
R3 should equal *R2*.

Complementary error corrector

A-110 All inputs at zero. *Vs* handcrank OUT.
Turn *E* until *E2* equals 80.00.
Changing *Ds* to either 100 or 900 should reduce *E2* to the same reading.
A-107 Changing *Ds* to either 100 or 900 should reduce *E2* to 67.25.

Range rate corrector

A-108, A-109 All inputs at zero. Insert setting rod.

Horizontal wind component solver

A-157 *Sw* at zero. Mark *Ywgr* follow-up. Change wind direction.
Ywgr should not change.
A-105 *Bws* at 90. *Ds* at 500. All other inputs at zero. Run *Sw* to 60.
Ywgr should not change.

Elevation wind component solver

A-100 *Br* and *Bws* at 90. *Ds* at 500. All other inputs at zero.
Range near 17,000.
Change *E* to run *E2* near 80.
R2 should not change.

A-106 Set *E2* at 78.947. Run *Ywgr* between limits.
R2 should not change.

Train parallax

A-52 *Dd*, *B'gr*, *E2*, and *L* at zero. *R2* at maximum.
Ph dial should read zero.

A-243 Set *E2* at 70°. Run *R2* to minimum.
Ph should not change.

A-49 *Dd*, *B'gr*, *L*, and *E2* at zero. *R2* at maximum. Change *E2* from 0 to 90.
Ph should not change.

A-156 *Dd*, *E2*, and *L* at zero. *B'gr* at 90. *R2* at 1560.
Ph should read RIGHT 3°40'.

A-3 *Dd*, *L* at zero. *B'gr* at 90. *E2* at 60. *R2* at 1560.
Ph should read RIGHT 7°20'.

Relative motion group

A-524 *dR* limits ±450.

A-163 *So*, *Sh*, *dH*, and *E* at zero. *Br* and *A* at 90.
dR should read zero.

A-192 *Sh* at 0. Change *A* through 360°.
dR should not change.

A-127 *So* at 0. Change *Br* through 360°.
dR should not change.

A-532 *A* at 90. Change *Sh* from 0 to 400.
dR should not change.

A-194 *Br* at 90. Change *So* from 0 to 45.
dR should not change.

A-123 *E* at 0. Change *dH* from −250 to +150.
dR should not change.

A-125, A-126 *So*, *Sh*, and *dH* at zero. Change *E* from 0 to 85.
dR should not change.

A-128 *E* at 60, *Br* at 90, *A* at 0, *Sh* at 400, *So* and *dH* at 0.
dR should read −200.

A-126 *E* at 30. *A*, *Br*, *Sh*, and *So* at zero. *dH* at −240.
dR should be −120.

Deck tilt section

A-62 *L*, *Zd*, and *B'r* at zero.
Br should read zero.

A-99 *B'r* at 45. Change *L* from 500 to 3500.
A-64 should not move.

A-28 *L* at zero. Change *B'r* through 360°.
A-64 should not move.

A-64 *B'r* and *L* at zero. Change *Zd* from 500 to 3500.
jB'r should not change.

A-57 *B'r* at zero. Change *L* from 500 to 3500.
A-62 should not move.

A-111 *Zd* at zero. *B'r* at 90. Change *L* from 500 to 3500.
jB'r should not change.

A-65 *Zd* at zero. *B'r* at 45. Set *L* first at 800 and then at 3200.
Br should read 46°21′ in both cases.

Trunnion tilt section

A-63 *Ds*, *Eb*, *L*, *Zd*, *Vs* at zero.
Vz should read zero.

A-113 *Zd* at zero. Change *Ds* from 100 to 900.
Vz should not change.

A-208 *Ds*, *Eb*, *Vs* at zero. Change *Zd* from 800 to 3200.
Vz should not change.

A-112 *Ds*, *L*, and *Vs* at zero. *Eb* at 60. Set *Zd* first at 800 and then at 3200.
Vz should read same value on plus side in both cases.

A-32 *Ds*, *L*, and *Vs* at zero. *Eb* at 60. Set *Zd* first at 800 and then at 3200.
Vz should read +316 in both cases.

A-33 *Ds*, *L*, *Zd*, *Vs*, *Eb*, *E2* at zero.
Dd should read zero.

A-35 *L*, *Zd*, and *Vs* at zero. Change *Eb* from 0 to 60.
A-216 gearing should not move.

A-36 *Ds*, *L*, *Zd*, *Vs* at zero. Change *E2* from 0 to 80.
A-215 gearing should not move.

A-34 *L*, *Zd*, and *Vs* at zero. *E2* at 60.
Set *Ds* at 700. *Dd* should read +23°35′.
Set *Ds* at 300. *Dd* should read −23°35′.

A-61 *Ds*, *Vs*, and *L* at zero. *Eb* at 60.
Set *Zd* at 3200. *Dd* should read +30°34′.
Set *Zd* at 800. *Dd* should read −30°34′.

Part four

READJUSTMENT PROCEDURE

Introduction

This section serves as a reference for all adjustment points in the Computer Mk 1, Mods 0-4, 6-10, 12, and 13, and the Star Shell Computer Mk 1, Mods 0, 1, and 2.

The introductory chapter on *Covers* gives information about the construction and securing devices of the covers and cover windows, together with precautions to be observed when removing, handling, and replacing these parts.

All adjustment points and assembly clamps are listed in numerical order for ready reference. The location, method of checking, and adjustment procedure are given for each adjustment. In most cases, the check and adjustment procedure depend upon other parts of the instrument being operative and in correct adjustment.

The necessity for readjustment is made evident only through trouble analysis. The chapters which deal with analysis of test errors and unit check tests contain a carefully worked-out procedure for locating adjustment trouble. Also, the chapters on removal and replacement of mechanisms contain lists of adjustments to be remade or checked. In all of these cases the adjustment numbers are listed in a definite sequence which, when followed, will expedite the job. In order to avoid possible damage to the mechanism, it is advisable for all maintenance personnel, no matter how well experienced, to follow this sequence carefully.

The partial schematic diagram which accompanies each adjustment is intended to show the units and other adjustments which would be affected. If any extensive readjustment is necessary, however, reference should be made to the complete schematic diagram in order to gain an over-all picture of the job.

It is not advisable to use the readjustment procedure as a reference if an instrument must be completely readjusted, that is, if it was dismantled and reassembled with all adjustment clamps left loose. In such a case, refer to *Factory Adjustment Procedure,* page 815.

The readjustment procedure gives an individual check for each numbered adjustment. In the check, the necessary computer setup and procedure are given for determining the accuracy of the adjustment. If the results of the check are unsatisfactory, the readjustment should then be made, using the *same setup.*

In some cases, locational directions are given with respect to the right, left, front, or rear of the instrument. These should not be confused with the *apparent* right, left, front, or rear of any part of the instrument as viewed through an access opening. The directions used for reference are explained in the chapter on *Covers.*

In making most of the adjustments, it is helpful to make the clamp slip-tight. When a clamp is slip-tightened properly, the adjustment can be slipped with light pressure, but it is tight enough to hold while the check is made. In this way, critical adjustments can be made a little at a time, gradually approaching the correct position. Then, since the clamp is slip-tight, a slight additional turn of the clamping screw will make the clamp fully tight without disturbing the adjustment.

Usually, when an adjustment is slip-tight, the related parts are brought into position by turning the gearing. A gear-pusher may be used for this purpose. Such a tool should be made of *soft metal,* such as aluminum, and should have a wedge-shaped end which can be applied to the base of a gear tooth in order to turn the gear. *Never touch gear teeth with hard metal such as a screw-driver blade.*

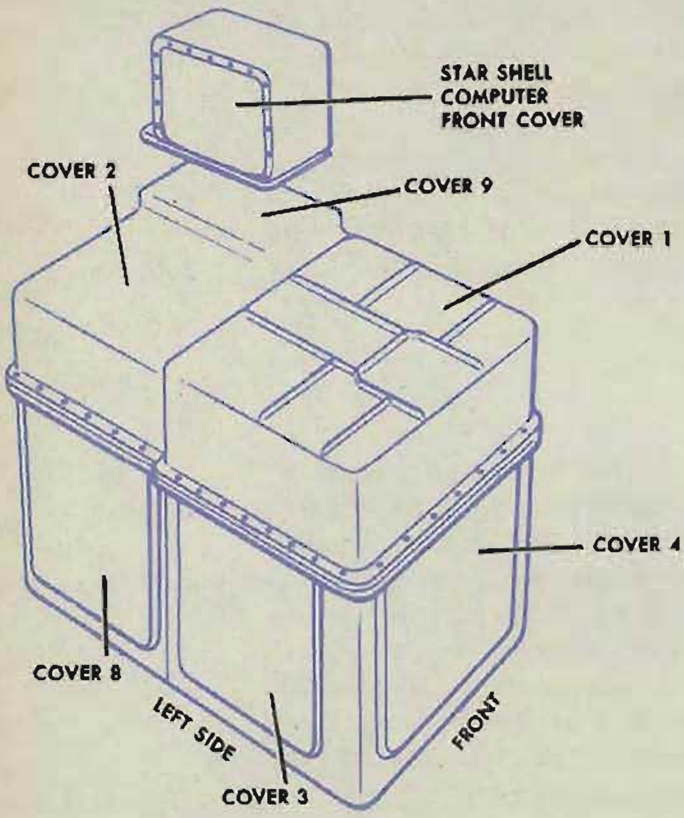
When making setups of various quantities, it is often desirable to wedge shaft lines in position temporarily. This may be done by inserting a wedge between the side of a gear and a fixed hanger or plate. The wedges may be of material such as linen bakelite. It is advisable to have a supply of wedges on hand for use during checks and readjustments. Avoid the use of bits of wood or metal, as they may leave chips in the instrument or damage finished surfaces. When using a wedge, make sure that the parts being wedged are substantial. *Never wedge differentials or counters.* The wedge should be inserted with light pressure only, never hammered in place. If the proper location for wedging is selected, light pressure will create enough friction to hold the line.

In making some adjustments, a dial indicator is used to measure motion of parts. Any suitable indicator which reads to 0.001 inch may be used. It should be clamped in place so as to read true motion of the part being observed. For example, in the adjustment of A-126, an indicator is used to measure motion of the *dH* sin *E* rack. If the type of indicator having a pivoted contact arm is used, the arm should be set perpendicular to the direction of motion of the rack. If the plunger type of indicator is used, the plunger should be parallel to the direction of motion of the rack.

When an adjustment calls for setting a synchro motor or generator on electrical zero, a standard motor (test synchro) should be used. Refer to page 183 for instructions on connecting a standard motor to the instrument wiring. If it is connected to a synchro motor, the standard motor may be used to hold the electrical zero position of the synchro while the adjustment is made. If it is connected to a synchro generator, the standard motor will indicate the position of the generator rotor, which may then be manually positioned at electrical zero by turning and wedging the gearing.

In the special case of the star shell differential generators, two standard motors may be used to set electrical zero. The stator leads of one standard motor are connected to the *stator* leads of the differential generator. This motor should be held on electrical zero. The stator leads of the other standard motor are connected to the *rotor* leads of the differential generator. This second motor will then indicate the position of the generator rotor, which may be manually positioned at electrical zero by turning and wedging the gearing. When two standard motors are used in this way, it is important that both be energized from the same source, with proper regard to polarity of the rotor leads.

THE COMPUTER COVERS

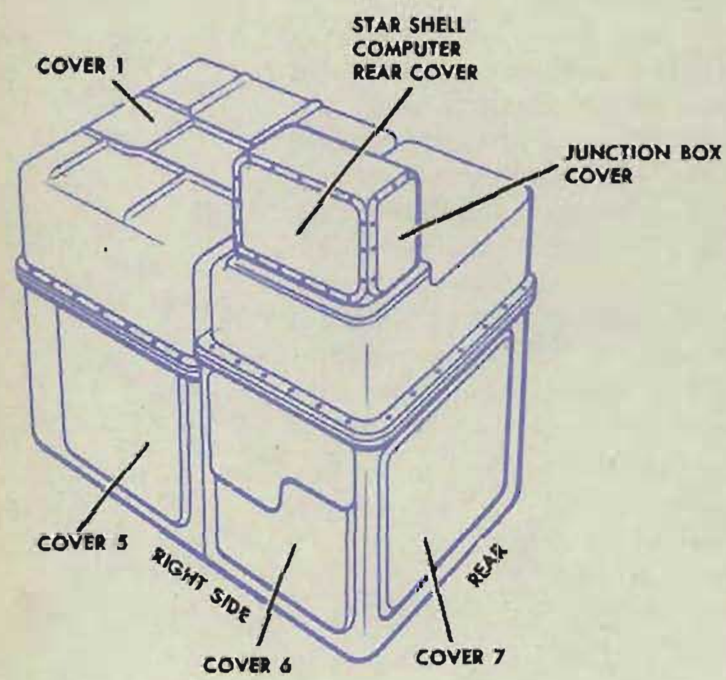


Location

The Computer Mark 1 has nine covers located as shown in the sketches.

On later instruments, cover 1 has a small cover on the right side for access to the time motor regulator.

Cover 9 is used only when a star shell computer is not supplied.



The Star Shell Computer Mark 1 has three covers: one in front, one in rear, and one over the junction box.

Note that the Computer Mark 1 and the star shell computer do not face in the same direction. The FRONT of the star shell computer faces in the direction of the LEFT side of the Computer Mark 1. Thus, the front cover of the star shell computer faces the left side of the computer, the rear cover faces the right side of the computer, and the junction box cover faces the rear of the computer.

When repairs or adjustments are to be made inside the computer, some or all of the covers must be removed, but no cover should be kept off the computer unless work is actually in progress under that particular cover.

THE COVER FITTINGS

Studs and nuts are used to hold the covers in place except in special construction where socket head screws are used. The studs are threaded at each end and have an unthreaded section in the middle. They are permanently screwed into the computer frame and protrude through the holes in the covers.

Cap nuts (usually called acorn nuts) are screwed on the studs to secure the covers in place.

A cover washer and a lock washer are always used between the cover and each acorn nut.

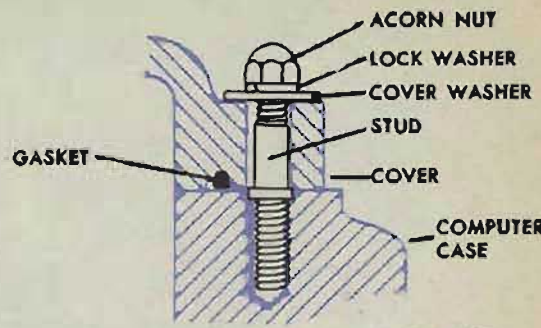
Elongated acorn nuts are used for accessibility instead of regular acorn nuts on the four studs that secure cover 1 in the narrow space between the front and the rear sections of the computer.

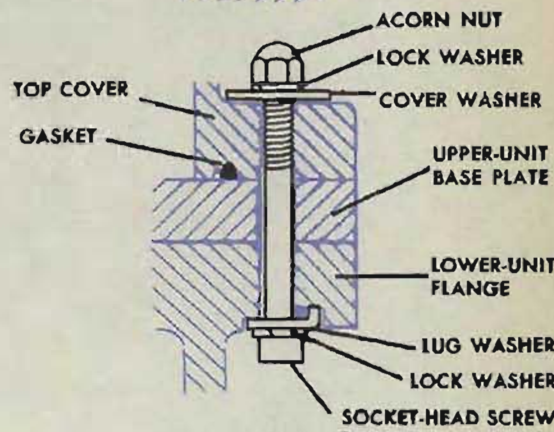
Socket-head screws are used where the sides of the top cover must be secured to a flange of the lower unit. The socket-head screw goes through holes in the lower-unit flange, the upper-unit base plate, and the top-cover flange. A lug washer and a lock washer are used between the head of the screw and the flange, and a cover washer and lock washer are used between the acorn nut and the cover.

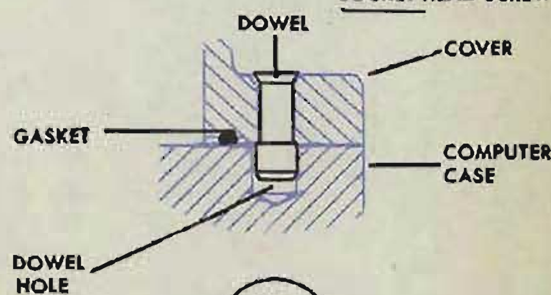
Dowels are used to position the covers that have handcranks on them: Covers 1, 2, and 3 on the Computer Mark 1, and the front cover of the star shell computer. A dowel is riveted to a cover and projects from it. The dowels fit snugly into holes in the computer case, thus positioning the covers accurately.

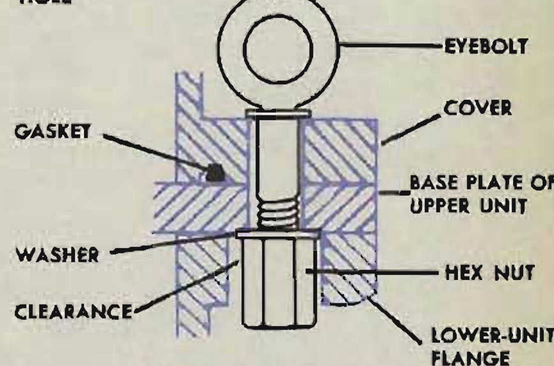
Eyebolts are provided to lift the upper units of the computer off the lower units. There are four of these eyebolts on cover 1 and four on cover 2. They go through the cover and the base plate of the upper unit, and must be removed before removing covers 1 and 2.

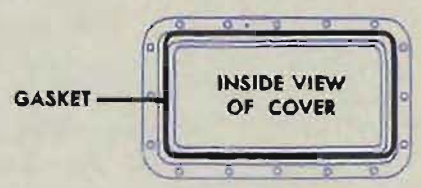
A gasket made of rubber or neoprene is cemented into a small groove within a larger groove around the inside edge of each cover. The gasket protrudes about 1/8 inch from the larger groove. When the cover is tightened, the gasket is compressed and expands laterally into the larger groove. Sometimes the gaskets stick to the computer case. Graphite applied to the computer case will help prevent the gasket from sticking.

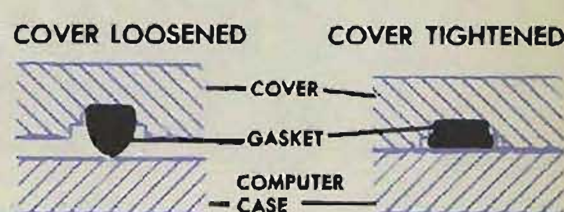




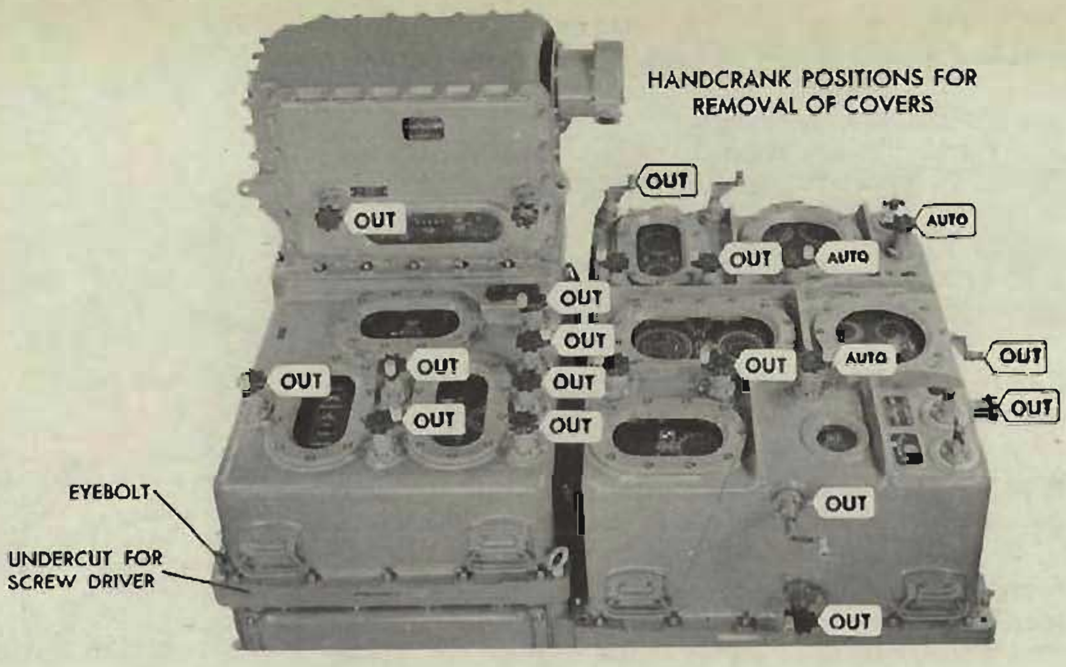


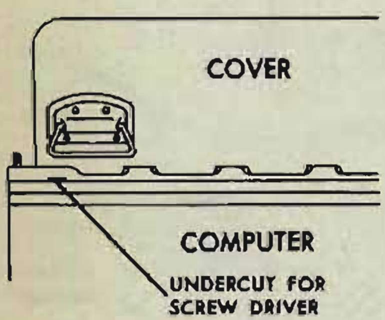






Gene Slover's US Navy Pages
Table of Contents

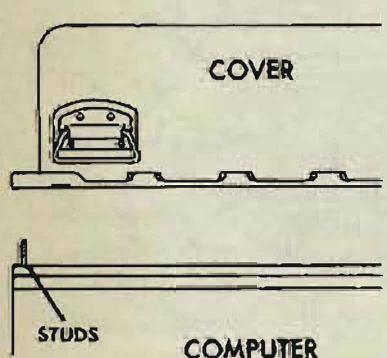




Removing a cover

Lock all handcranks on the cover at their OUT or AUTO positions. The handcranks come off with the cover.
Remove all the cap nuts and washers around the cover.
Before removing covers 1 and 2, turn the power switch OFF and take out the eyebolts at the corners.
Put a screw driver into each undercut along the edge of the cover near the corners. Pry the cover loose gradually. Use the lifting handles on covers 1 and 2. Keep the cover straight while removing it. Be sure to clear all mechanisms before moving the cover sideways.
The threads on the studs are sharp and may cause damage to body or clothing. It is advisable to replace the acorn nuts on the studs before working inside the computer.
In order to remove cover 2 when the star shell computer is mounted on it, the star shell computer must be removed.
CAUTION: Cover 1 is heavy and cumbersome. To avoid possible damage to the mechanisms under this cover, four men should handle it during removal.

Replacing a cover

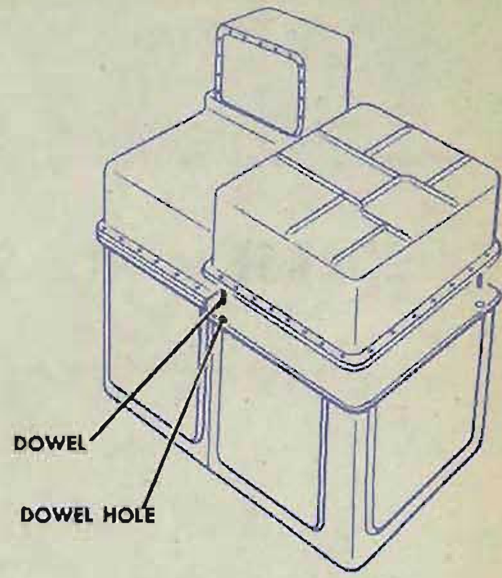


As soon as work is finished inside a unit of the computer, replace the cover of that unit to prevent dirt from getting inside. Before replacing a cover, inspect the cover gasket for damage. If there are breaks in the gasket, take it out, clean the contacting surfaces, and cement a new one in its place. In replacing a cover with handcranks on it, make sure that all the handcranks are locked in their OUT or AUTO positions. Position the cover so that it goes on straight. If there are dowels in the cover, lubricate the dowels with grease and line up the cover so that the dowels slide easily into the holes in the case. Don't try to force the dowels into the holes.

Don't let the covers rest on the stud ends. This may strip the threads of the studs and damage the stud holes. The aluminum chips from the cover may then get into the computer.

When the cover is on, finger-tighten all the cap nuts. Then tighten each nut slightly with a socket wrench. Go around the cover, tightening the nuts evenly until all the nuts are taken up securely. Tightening each nut fully as soon as it is put on a stud may warp the cover.

CAUTION: Some of the handcrank gears are meshed in the OUT position. Make sure these gears are in mesh as the cover is being seated. Check the mesh by turning the handcranks.



BEFORE SEATING COVER:

1. CLEAN OFF THE CONTACTING SURFACES
2. LUBRICATE THE DOWELS WITH GREASE

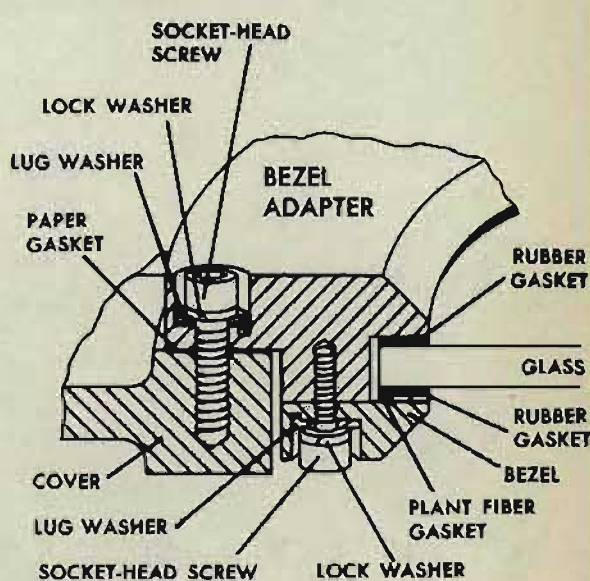
The windows in the covers

The glass in the windows of the covers may have to be replaced occasionally because of discoloration or breakage.

There are two types of windows: those that can be removed from the outside of the cover, and those that can be removed only from the inside of the cover.

Windows attached to outside of a cover

The windows that can be removed from the outside are held between two frames: a bezel on the underside and a bezel adapter on the top. The arrangement of the watertight window gaskets is important. There is a rubber gasket between the bezel adapter and the glass, and a rubber gasket plus a fiber gasket between the glass and the bezel. Socket-head screws hold the assembly together.

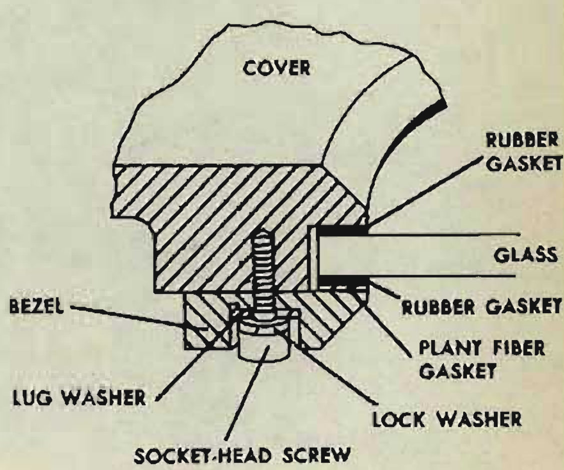


The window assembly is attached to the computer cover with socket-head screws which go through the rim of the bezel adapter and are threaded into the computer cover.

To remove the glass window without removing the cover, it is necessary first to remove the entire assembly from the cover in order to get at the bezel screws on the underside of the assembly.

Windows attached to inside of a cover

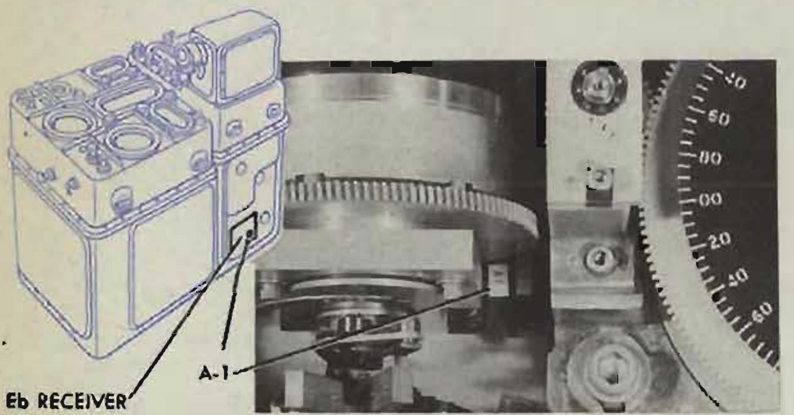
When a window is attached to the *inside* of a cover, the glass can be removed only after the cover in which it is located has been removed from the computer. A bezel usually holds the glass window against the inside of the cover and is secured in place by socket-head screws.



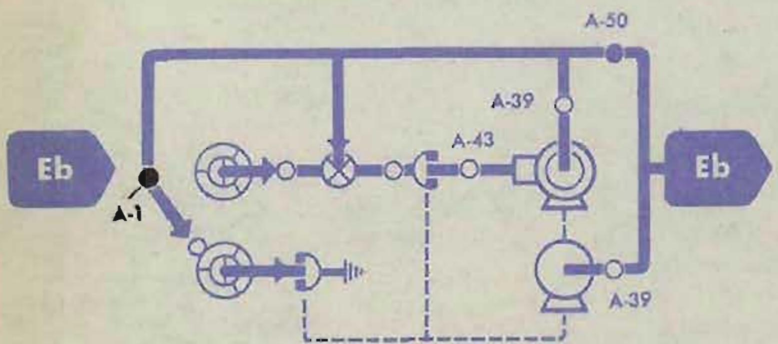
An examination of each type of window assembly will show the order in which to remove the parts and put them together again.

CLAMPS

A-1 COARSE to FINE SYNCHRO—Eb RECEIVER



DIRECTOR ELEVATION RECEIVER



Location

A-1 is under cover 6, on the horizontal worm behind the coarse *Eb* synchro.

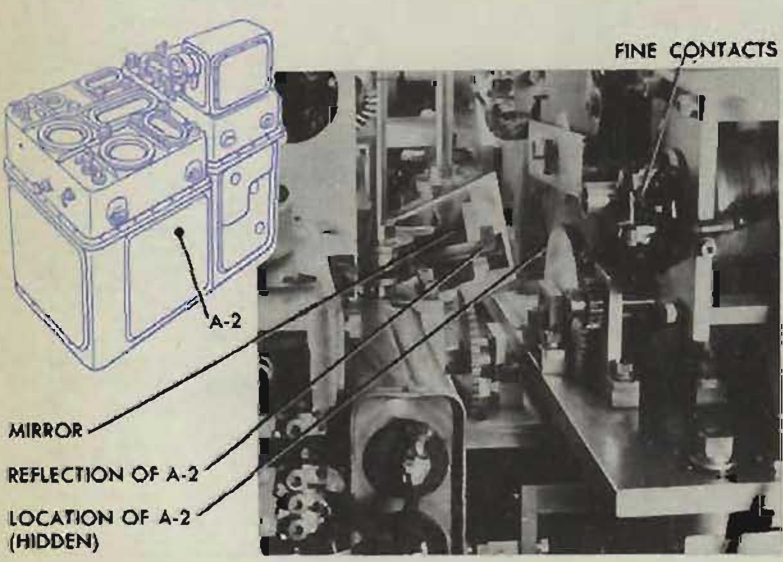
Check

Turn the power ON.
Transmit *Eb* from the director.
Allow the follow-up to synchronize.
The coarse center contact arm on the receiver should be centered between the scissor contacts.

Adjustment

If the contact arm is not centered between the scissor contacts, turn the power OFF, loosen A-1, and turn the worm until the contact is centered.
Tighten A-1 and recheck.
Readjust A-50.

A-2 COARSE to FINE SYNCHRO—Co RECEIVER



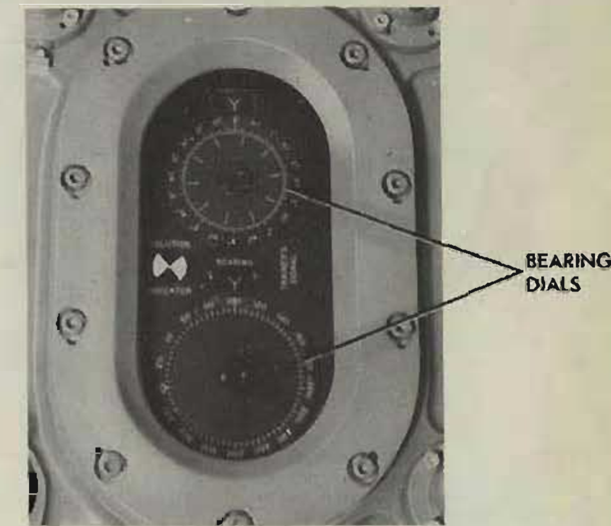
Location

A-2 is under cover 5, on the horizontal worm which meshes with the gear of the coarse *Co* synchro.

The clamp is 3 inches to the rear of the lower right end of the hanger on which a resistor is mounted, and 1/2 inch above the receiver mounting plate. It is visible only with a mirror and a pencil light.

Check

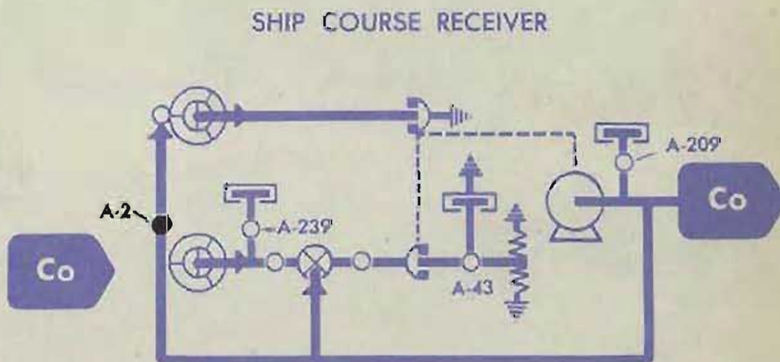
Turn the power ON.
Transmit *Co* from the gyro compass to the computer.
Put the *Co* handcrank in the OUT position.
Allow the follow-up to synchronize.
Turn the control switch to LOCAL.



The coarse contact arm should be centered between the scissor contacts on the receiver. Since it is difficult to observe the scissor contacts, check them by pushing the fine contact arm to each limit and observing, on the *Br* dials, the amount the follow-up drives each way from the centralized point.

Adjustment

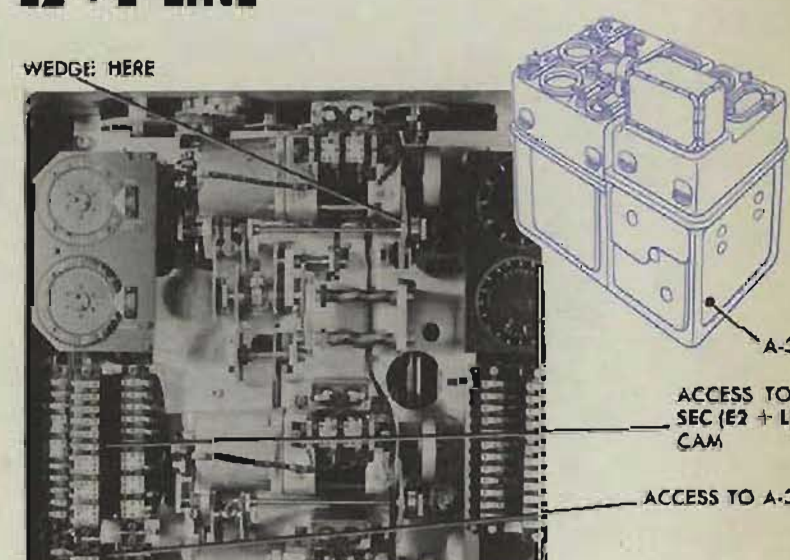
If the follow-up does not drive about the same amount in each direction, approximately 3° on the *Br* dials, loosen A-2. Reach A-2 by inserting a short screw driver between the housing of the differential and the post mounting the scissor arm contacts. Turn the worm until the coarse contact arm is centered. The centered position can be determined only by the trial and error method.
Tighten A-2.
Readjust A-179.



A-3 Ph COMPUTER to E2+L LINE

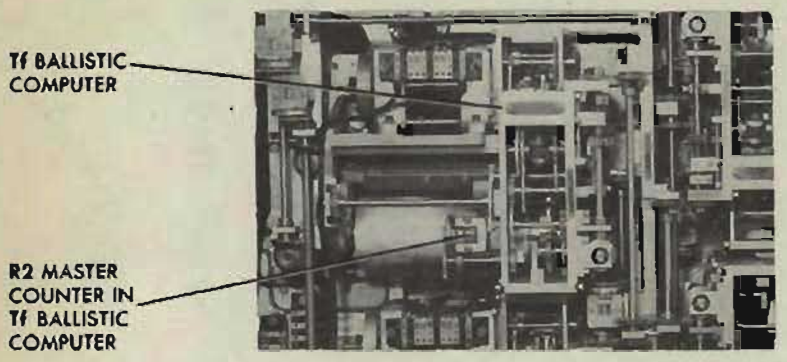
Location

A-3 is under cover 7, below the *Ph* computer. It may be seen by looking down at an angle past the lower end of the coarse *E'g* indicating transmitter.



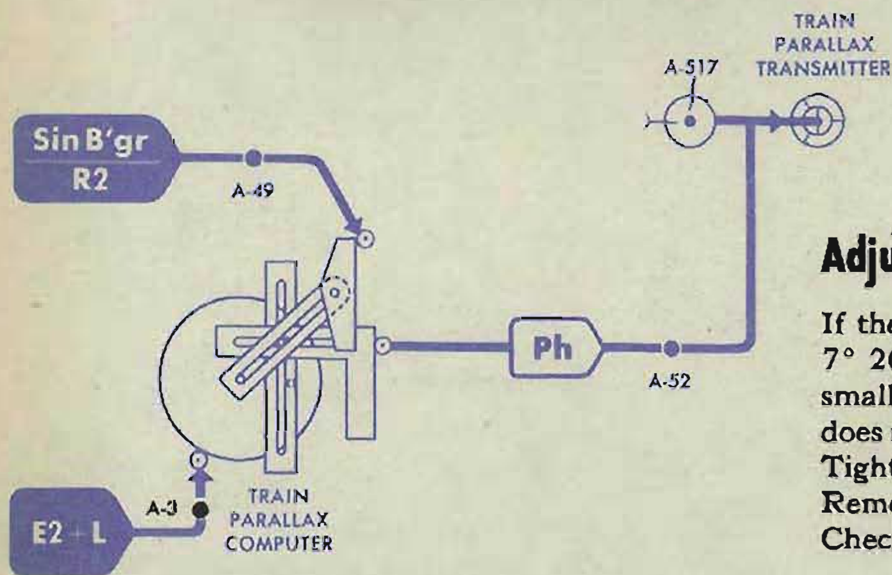
Check

Turn the power OFF.
Set *Dd* at 0° and wedge the line.
Set *B'r* and *B'gr* at 90°.



Set the *R2* master counter at 1560 yards and wedge the line.
Set *E2* at 60°.
Set *L* at 2000′ on the computer dials.
The *Ph* dial should read RIGHT 7° 20′.

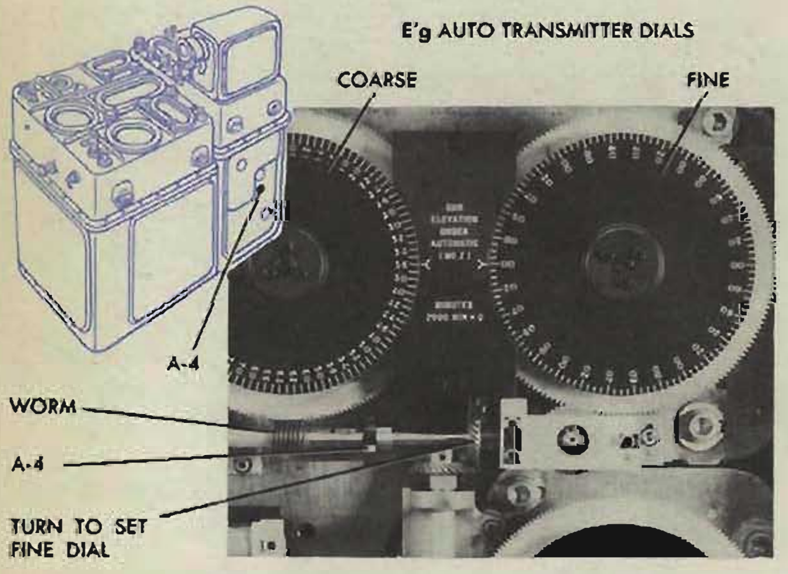
All Mods 0, and some early Mods 1 and 2, have *Ph* dials graduated in minutes. All others have *Ph* dials graduated in degrees and minutes.



Adjustment

If the *Ph* dial does not read RIGHT 7° 20′ make A-3 slip-tight. Turn the small gear under A-3 until the dial does read 7° 20′.
Tighten A-3 and recheck.
Remove wedges.
Check A-52.

A-4 COARSE to FINE SYNCHRO— E′g AUTO TRANSMITTER



Location

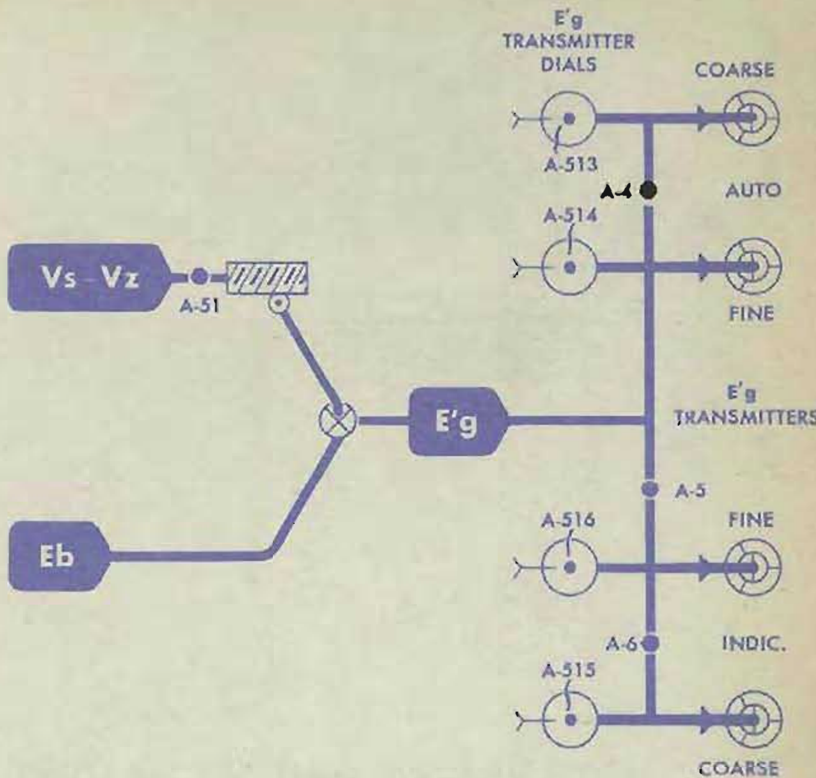
A-4 is under cover 6, on the worm beneath the *E′g* coarse auto transmitter dial.

Check

When the coarse dial reads 20, the fine dial should read 00.
Check A-513 and A-514 before readjusting A-4.

Adjustment

If the dials do not agree, turn the input shaft of the coarse auto transmitter until the coarse dial reads 20. Loosen A-4. Hold the worm to keep the coarse dial at 20 and turn the shaft until the fine dial reads 00. Tighten A-4 and recheck.



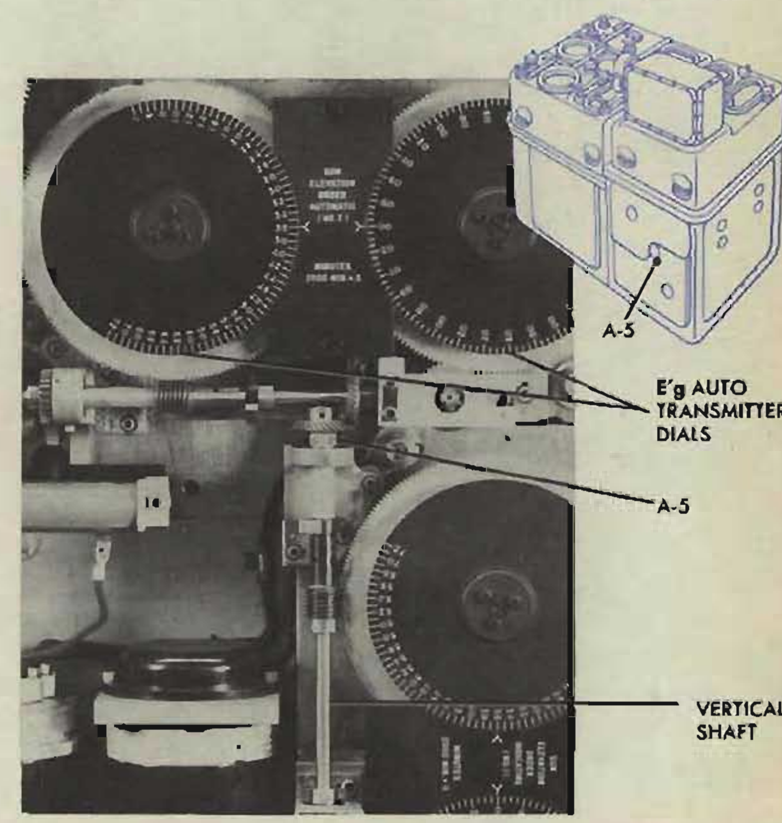
Note

There are six different graduations marked 00 on the fine dial. Check that the electrical zero graduation lines up with the 20 graduation on the coarse dial (A-514).
Check A-51 and A-5.

A-5 E'g INDICATING to E'g AUTO TRANSMITTER

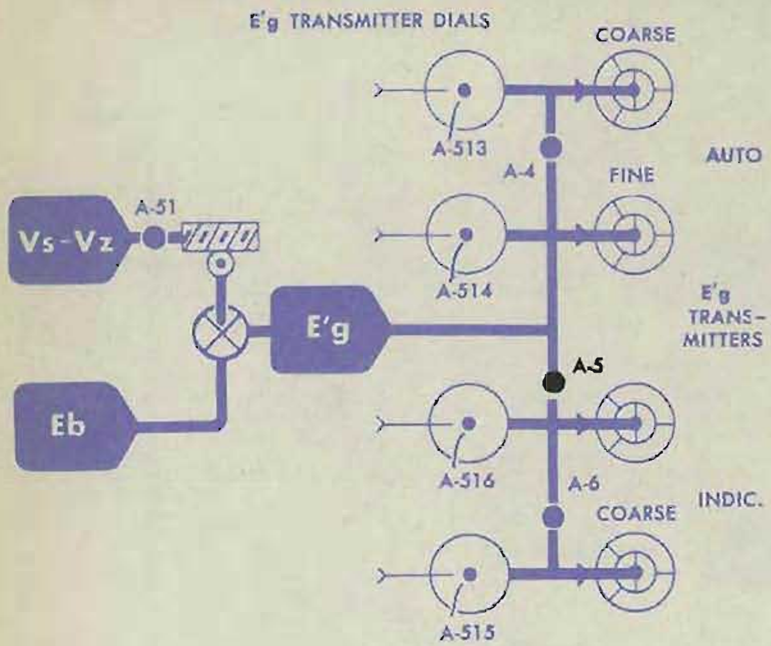
Location

A-5 is under cover 6, on the bevel gear below the *E'g* auto transmitter dials.



Check

The *E'g* indicating transmitter dials should read the same value as the *E'g* auto transmitter dials.



Adjustment

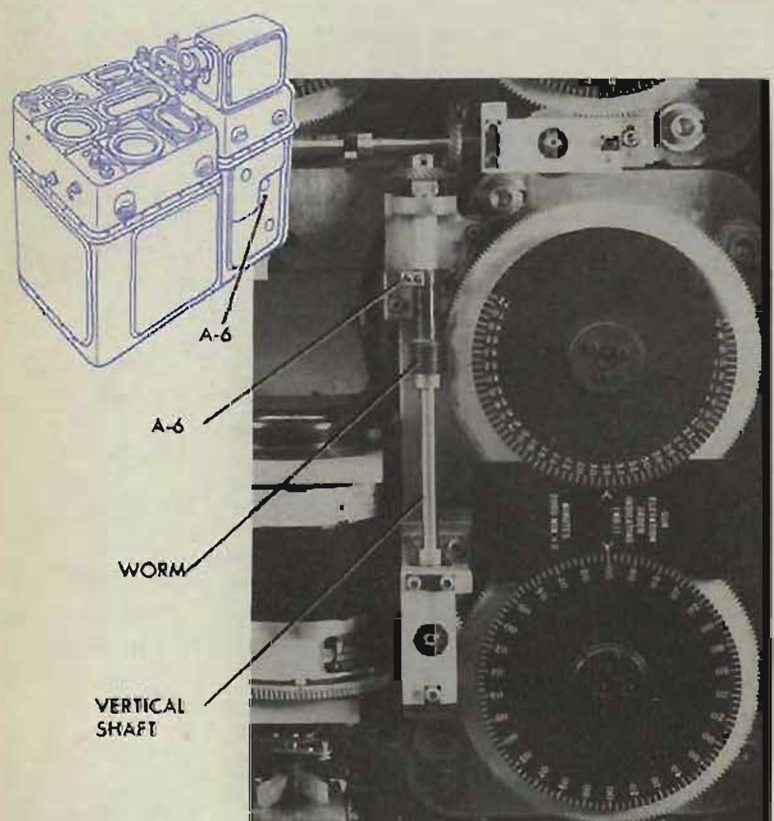
If the dial readings do not agree, loosen clamp A-5.

Turn the vertical shaft below the clamp until the indicating transmitter dials read the same value as the auto transmitter dials.

Tighten A-5 and recheck.

Check A-51 and A-6.

A-6 COARSE to FINE SYNCHRO—E'g INDICATING TRANSMITTER



Location

A-6 is under cover 6, on the worm to the coarse *E'g* indicating transmitter.

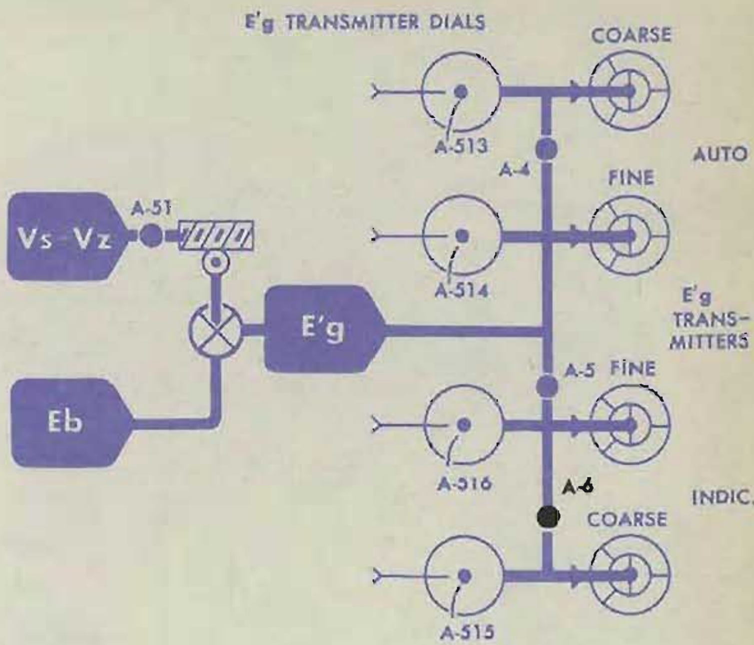
Check

When the coarse dial reads 20, the fine dial should read 00.
Check A-515 and A-516 before readjusting A-6.

Adjustment

If the dials do not agree, turn the input shaft of the coarse indicating transmitter until the coarse dial reads 20. Loosen A-6. Hold the worm to keep the coarse dial at 20, and turn the shaft until the fine dial reads 00.

Tighten A-6 and recheck.



Note

There are six different graduations marked 00 on the fine dial. Check that the electrical zero graduation lines up with the 20 graduation on the coarse dial (A-516).

Check A-5 and A-51.

A-7 COARSE to FINE SYNCHRO— B'gr AUTO TRANSMITTER

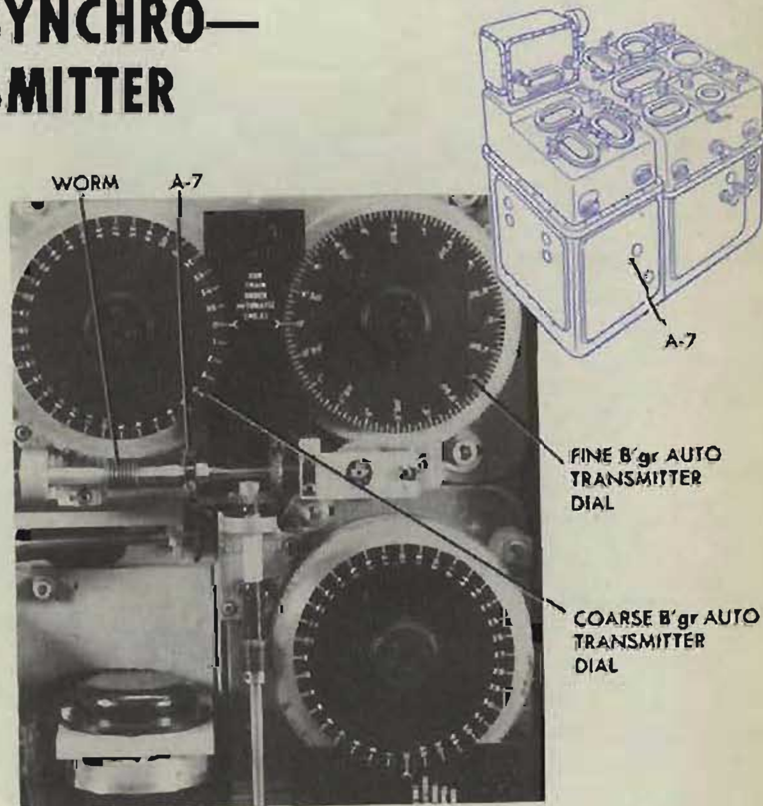
Location

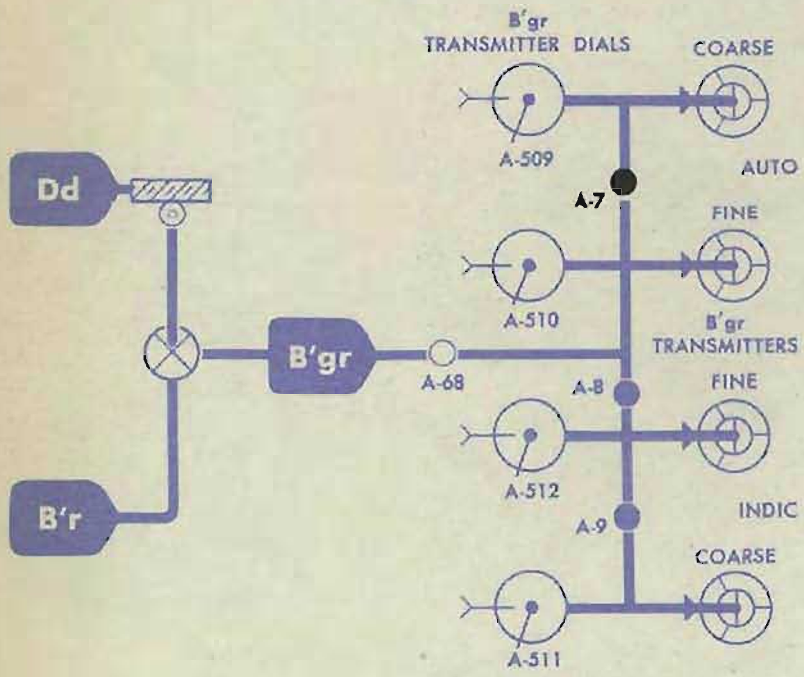
A-7 is on the worm beneath the coarse *B'gr* auto transmitter dial.

Check

When the coarse dial reads 0°, the fine dial should also read 0°.

Check A-509 and A-510 before readjusting A-7.





Adjustment

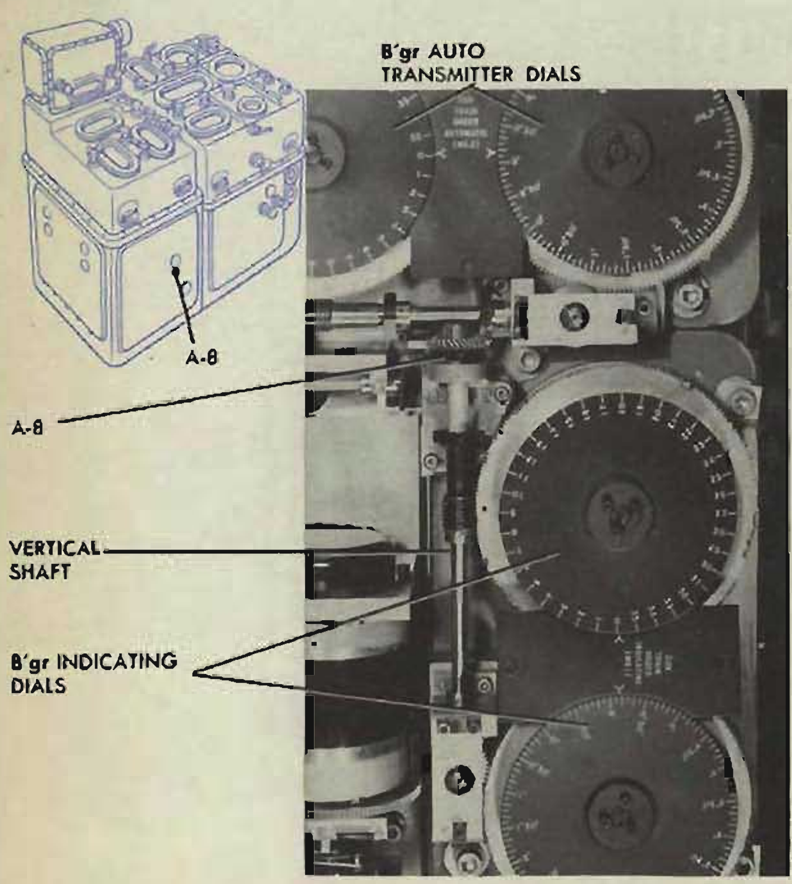
Set the coarse *B'gr* auto dial at 0°.

Loosen A-7.

Hold the worm and turn the shaft until the fine dial reads 0°. Tighten A-7 and recheck.

Check A-68.

A-8 B'gr INDICATING to B'gr AUTO TRANSMITTER



Location

A-8 is under cover 8.

Check

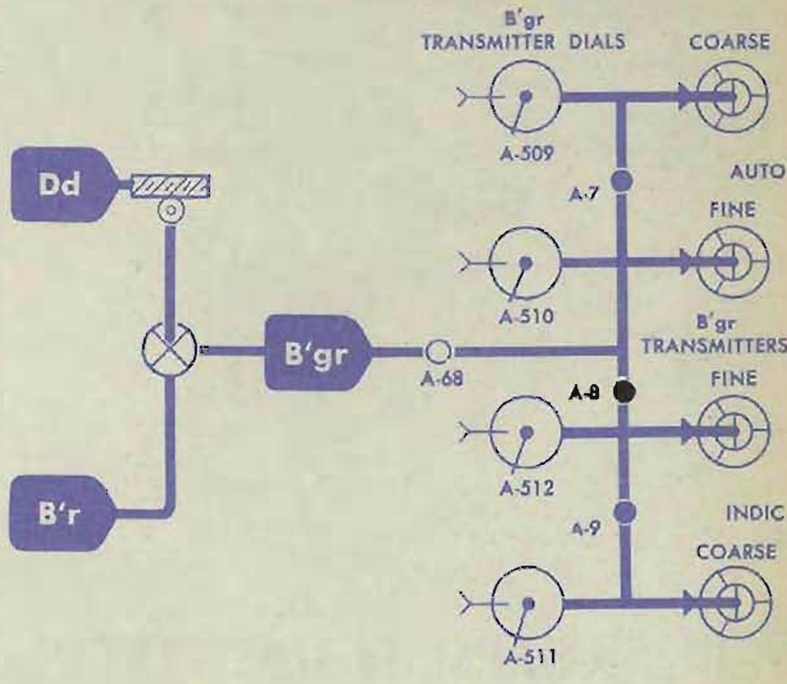
The *B'gr* auto and indicating transmitter dial readings should agree.

Adjustment

If the dial readings do not agree, loosen A-8 and turn the shaft below the clamp until the *B'gr* indicating dials read the same value as the *B'gr* auto dials.

Tighten A-8 and recheck.

Check A-68.



A-9 COARSE to FINE SYNCHRO — B'gr INDICATING TRANSMITTER

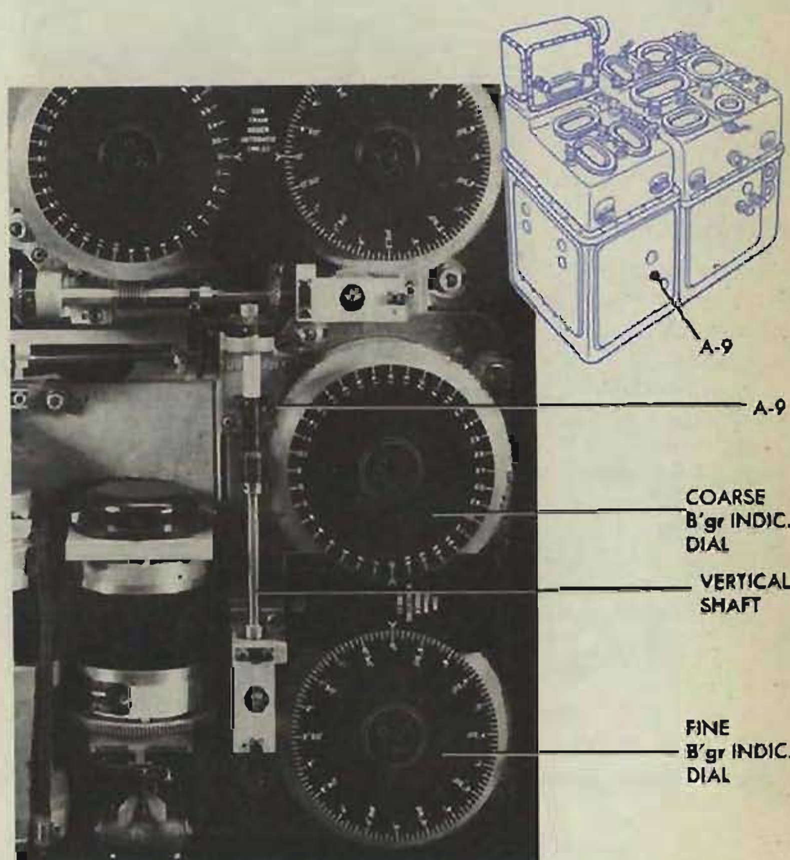
Location

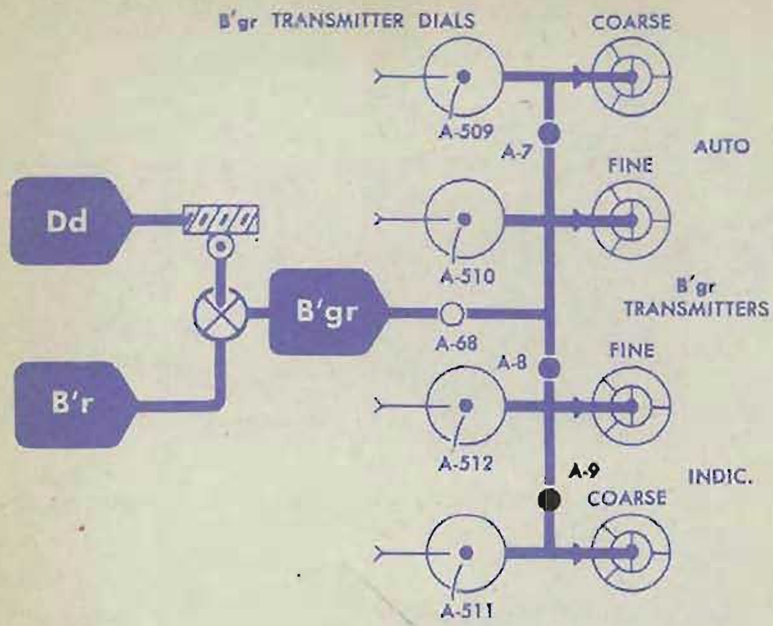
A-9 is under cover 8, on the worm to the coarse *B'gr* indicating transmitter.

Check

When the coarse dial reads 0°, the fine dial should read 0°.

Check A-511 and A-512 before readjusting A-9.





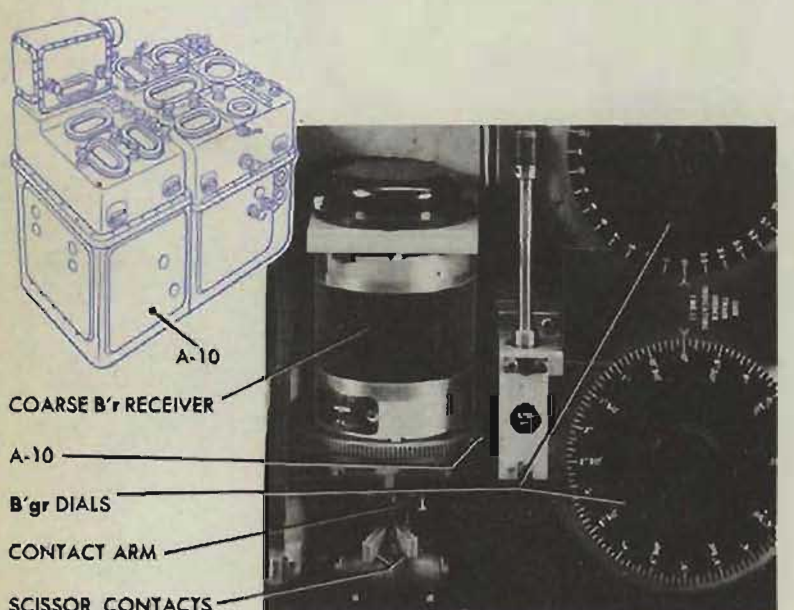
Adjustment

Set the coarse *B'gr* indicating dial at 0°. Loosen A-9. Hold the worm and turn the vertical shaft until the fine dial reads 0°.

Tighten A-9 and recheck.

Check A-8.

A-10 COARSE to FINE SYNCHRO—B'r RECEIVER



Location

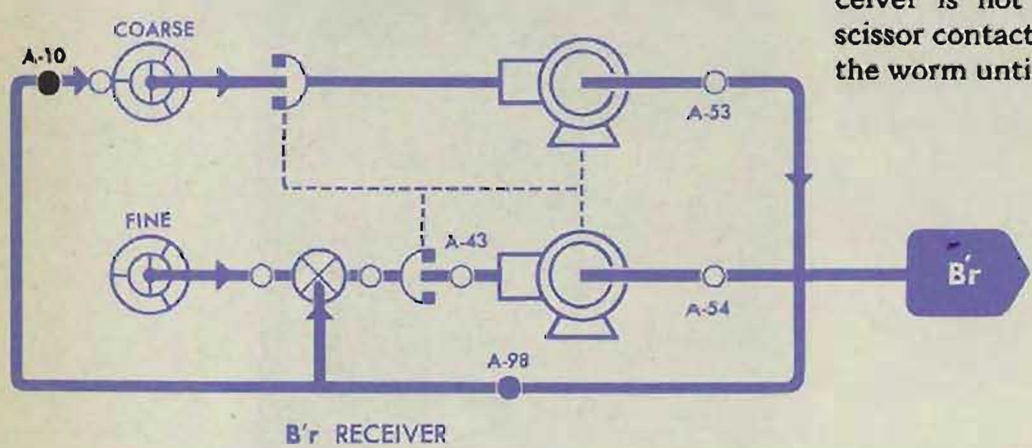
A-10 is under cover 8, on the worm behind the coarse *B'r* receiver.

Check

Turn the power ON.
Turn the control switch to SEMI-AUTO.
Transmit *B'r* from the director, and allow the follow-up to synchronize.
The coarse center contact on the receiver should be centered between the scissor contacts.

Adjustment

If the contact arm on the coarse receiver is not centered between the scissor contacts, loosen A-10 and turn the worm until the arm is centered.

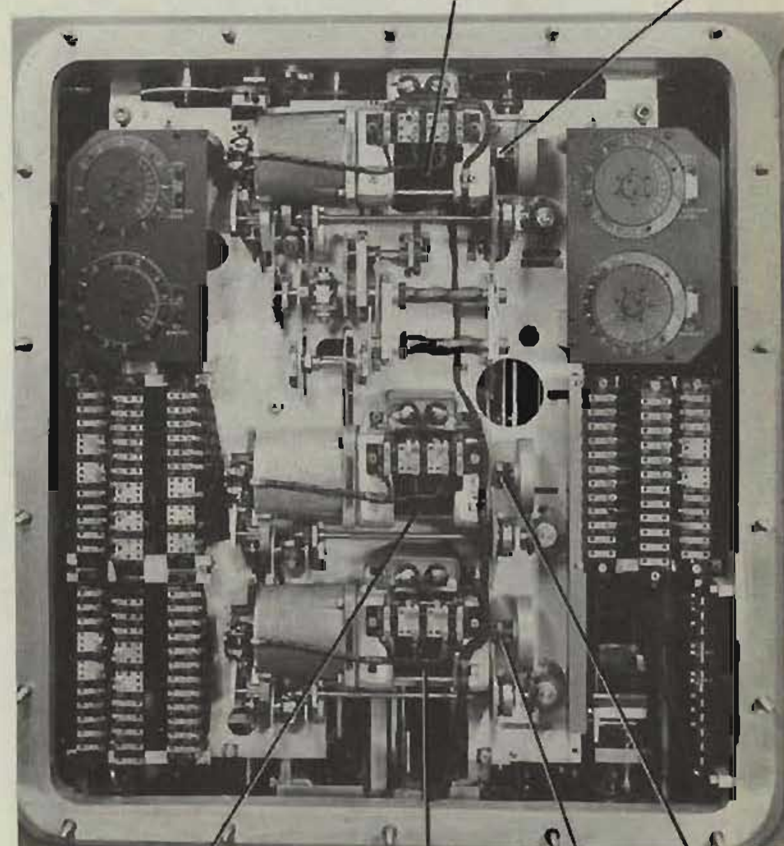


To check the setting, push the fine contact arm to each limit and observe the displacement of the *B'gr* dials. If the contact is centered, the displacement will be equal.

Tighten A-10 and recheck.

Check A-98.

A-11 ASSEMBLY CLAMPS



Location

Three assembly clamps numbered A-11 are located under cover 7. One is located on each of the three servo motor output shafts: *Dd*, *jB'r*, and *Vz*.

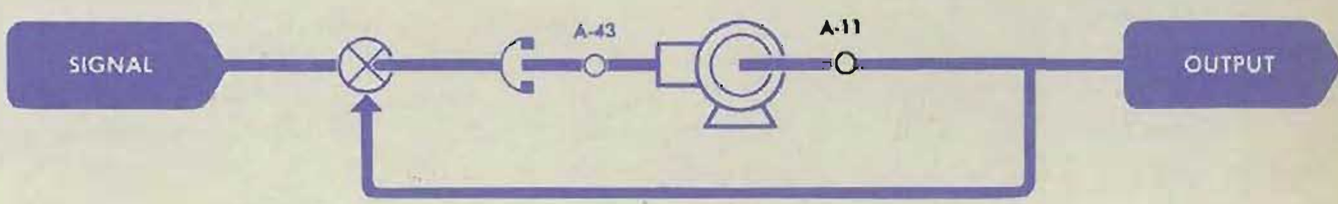
Check

If an A-11 clamp is loose, the servo may run away; that is, it may drive without limitation.

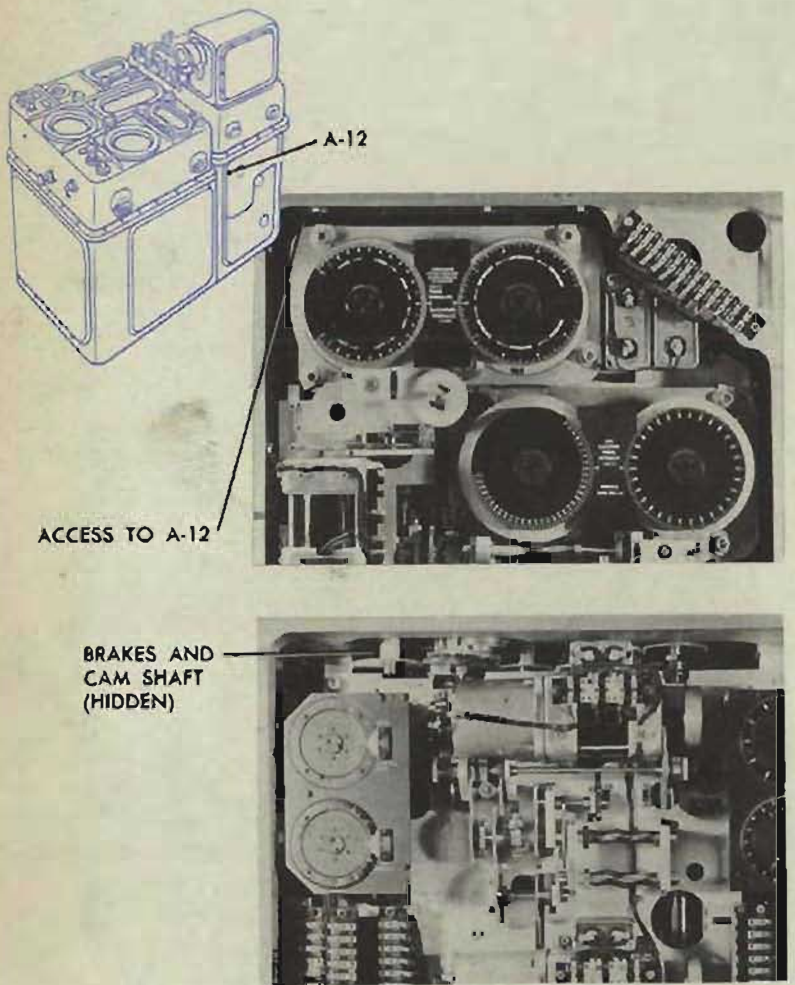
It will not drive the associated gear train because of slippage of the gear on which A-11 is mounted.

Adjustment

Tighten A-11.



A-12 FRICTION BRAKES to SYNC E HANDCRANK



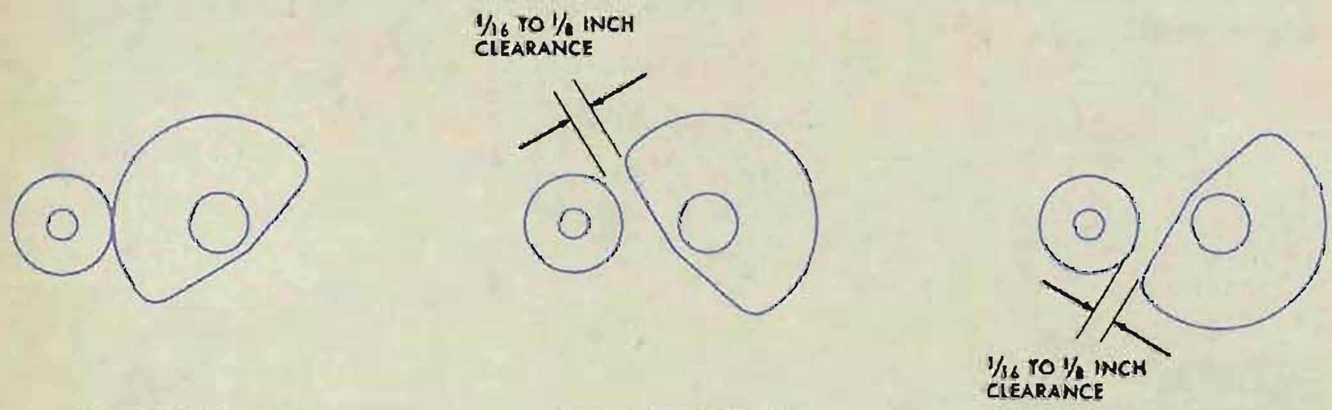
Location

A-12 is under cover 6, about 12 inches in, and is reached through an access at the upper front of the *Ph* transmitter. The brakes and cam shaft can be seen by removing cover 7 and looking into the computer directly above the *L* dials.

Check

Put the sync *E* handcrank IN and compare the position of the rear cam, nearest the back of the instrument, with the corresponding sketch of the cam, shown below. Do the same with the sync *E* handcrank in the CENTER, then in the OUT position.

With the sync *E* handcrank IN, the rear friction brake should be released and the front friction brake applied. With the handcrank in the CENTER and OUT positions, the rear brake should be applied, and the front brake released.



IN POSITION — REAR BRAKE RELEASED

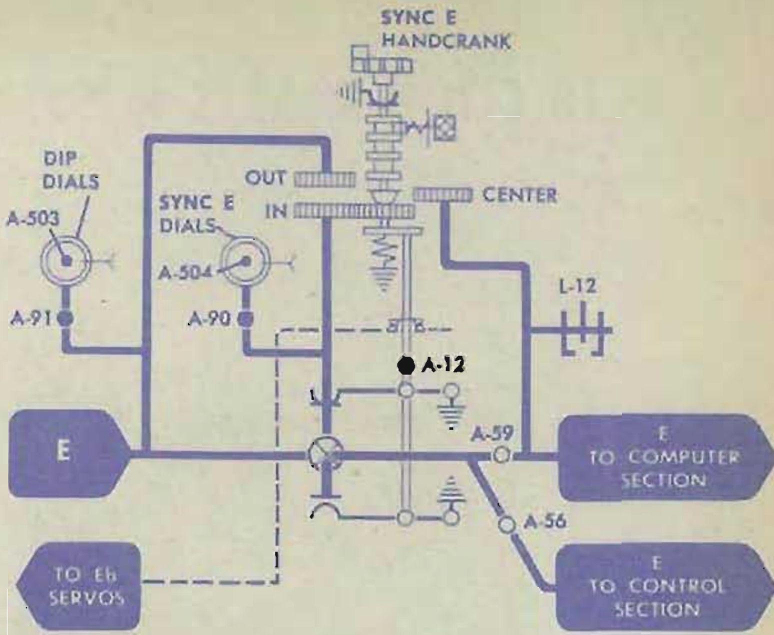
CENTER POSITION — REAR BRAKE APPLIED

OUT POSITION — REAR BRAKE APPLIED

RELATIVE POSITIONS OF REAR ROLLER AND CAM

Adjustment

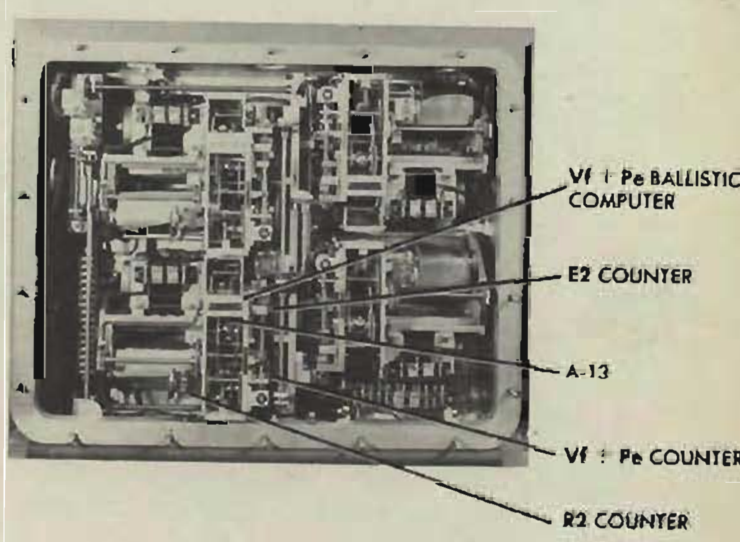
If the cams are adjusted incorrectly so that the brakes are applied and released improperly, put the sync *E* handcrank in the CENTER position. Make A-12 slip-tight. Using a gear pusher made of soft material such as aluminum, turn the bevel gear below A-12 until the rear cam is in the proper position shown in the sketch. Tighten A-12 and check the positions of the cam against the sketches when the sync *E* handcrank is at the IN and the OUT positions.



A-13 SYNCHRONIZING THE Vf + Pe FOLLOW-UP

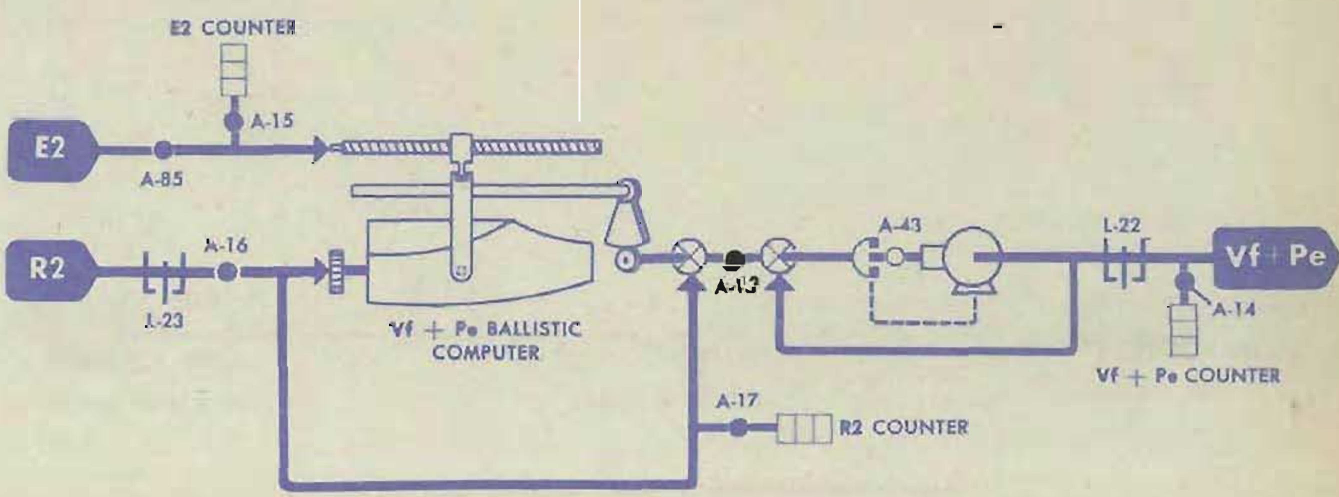
Location

A-13 is under cover 4, in the *Vf* + *Pe* ballistic computer.



Check

Refer to the N.I.O. final test sheet for the particular unit being checked.
Turn the power ON.
Set *E2* and *R2* at values given on the N.I.O. final test sheet.
Read the *Vf* + *Pe* unit counter and note any variation from the corresponding values recorded on the test sheet.
If the *Vf* + *Pe* value is *consistently less* or *consistently greater* than the recorded value, A-13 is in error and should be readjusted.



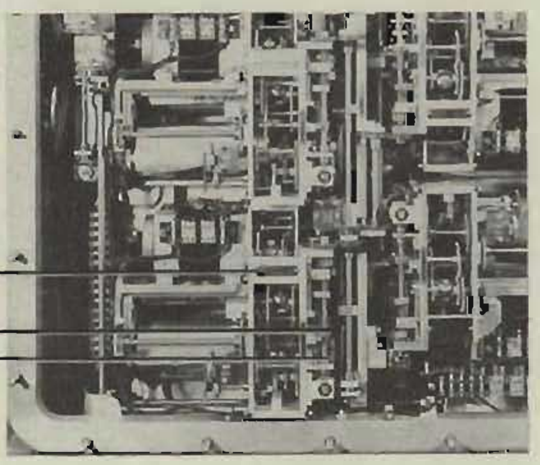
Adjustment

Loosen A-13. Turn the gear on which it is mounted to synchronize the follow-up at the correct value of $Vf + Pe$. Tighten A-13.

Refer to the N.I.O. final test sheets and run the complete test of the $Vf + Pe$ ballistic computer.

If necessary, A-13 may be readjusted slightly to improve the readings.

A-14 Vf + Pe COUNTER to L-22



Location

A-14 and L-22 are under cover 4, in the $Vf + Pe$ ballistic computer.

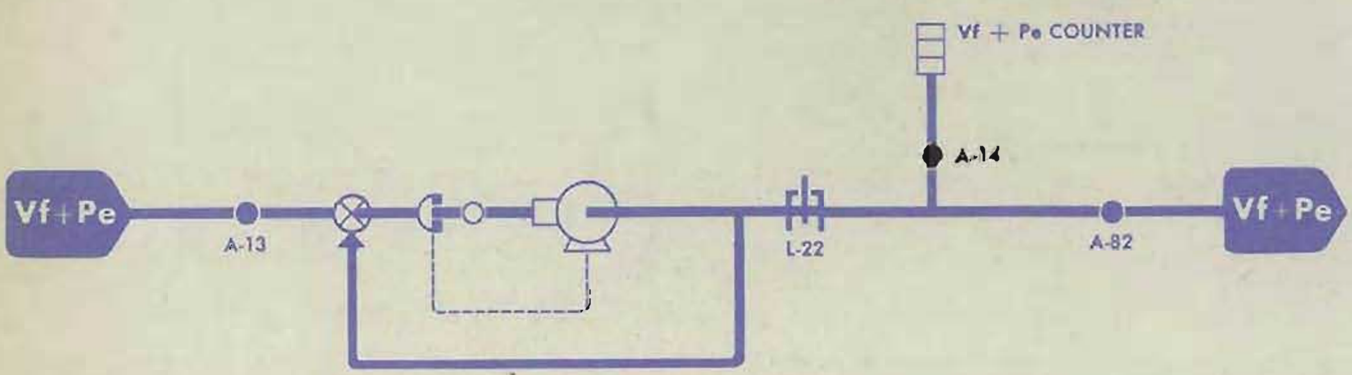
Check

Turn the power OFF.
Turn the $Vf + Pe$ ballistic computer output gearing from limit to limit.

The $Vf + Pe$ counter should read 0′ at the lower limit, and 2500′ at the upper limit. (On Mods 8 and 12, the limits are 0′ and 1800′.)

Adjustment

Loosen A-14.
Slip the counter to the correct reading.
Tighten A-14 and recheck.
Check A-13 and A-82.



A-15 E2 COUNTER to Vf + Pe BALLISTIC COMPUTER

Location

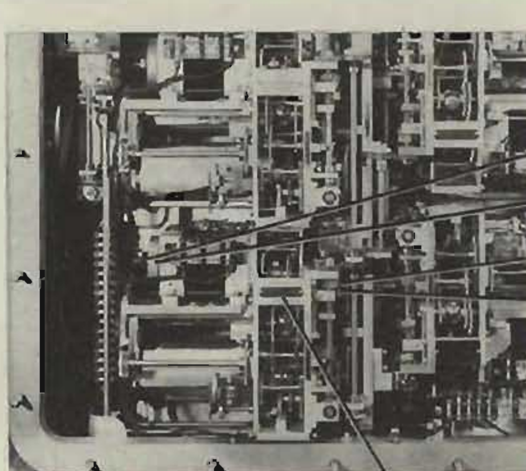
A-15 is under cover 4, in the *Vf + Pe* ballistic computer.

Check

Turn the power OFF.
Set *E2* and *R2* at the values listed on the setting rod legend plate.

Loosen A-209 on the *Vf + Pe* follow-up damper. Push the damper to the end of the shaft.

Insert a 3/16-inch setting rod through the casting, follower arm, and cam. If it is necessary to change the *E2* input to insert the setting rod, A-15 is upset and should be readjusted.



Adjustment

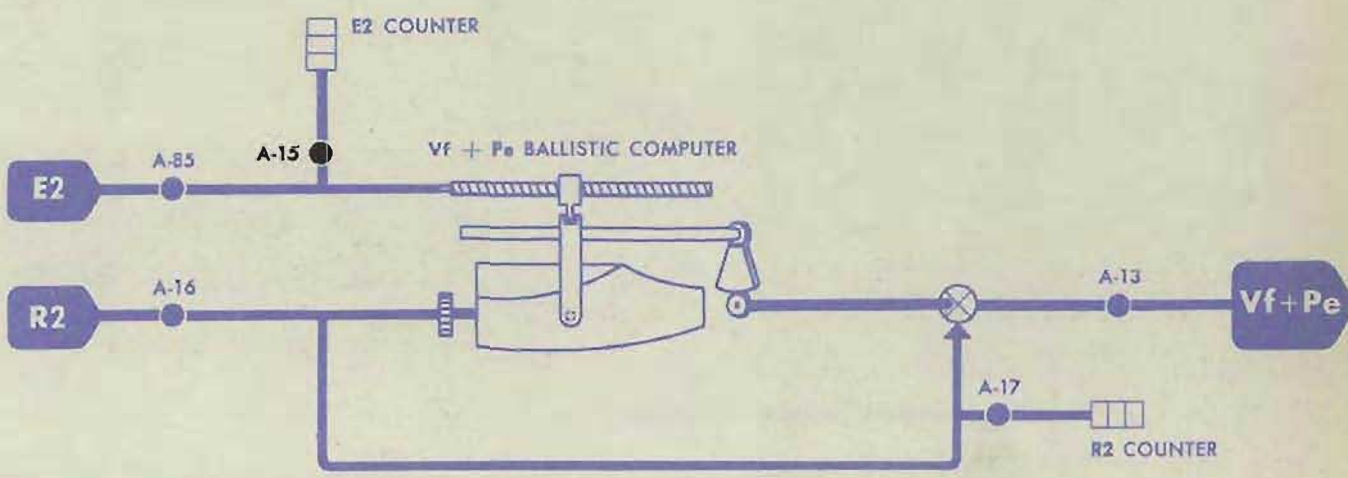
With the setting rod inserted, loosen A-15. Turn the *E2* counter until it reads the value specified on the legend plate. Tighten A-15 and recheck.

Remove the setting rod.

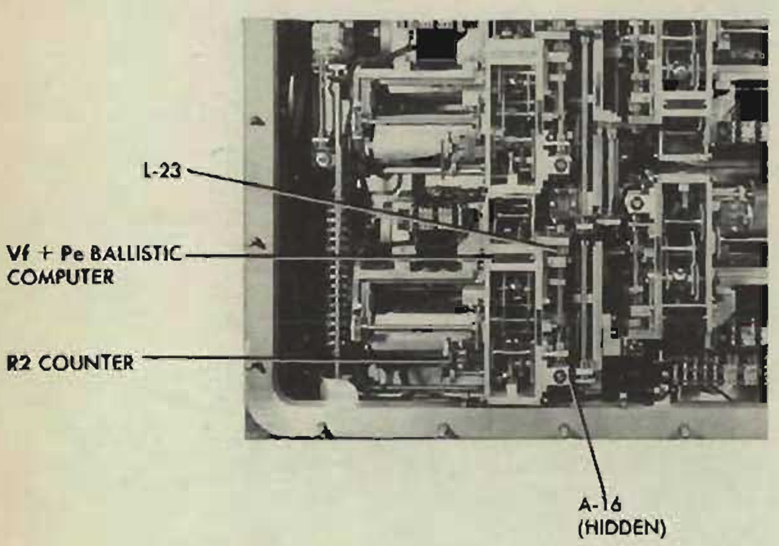
Replace the damper on the follow-up and tighten A-209.

Check that *E2* can be varied from 0° to 90°.

Check A-13 and A-85.



A-16 R2 COUNTER to L-23



Location

A-16 and L-23 are under cover 4, in the *Vf* + *Pe* ballistic computer.

Check

Turn the power OFF.
Loosen A-75.
Turn the *R2* input to the *Vf* + *Pe* ballistic computer from limit to limit.
The *R2* counter should read 300 yards at the lower limit and 18,200 yards at the upper limit on Mods 3, 4, 6, 7, 10, and 13. On Mods 0, 1, 2, and 9, the limits are 1,300 and 18,200 yards. On Mods 8 and 12, the limits are 300 and 20,200 yards.

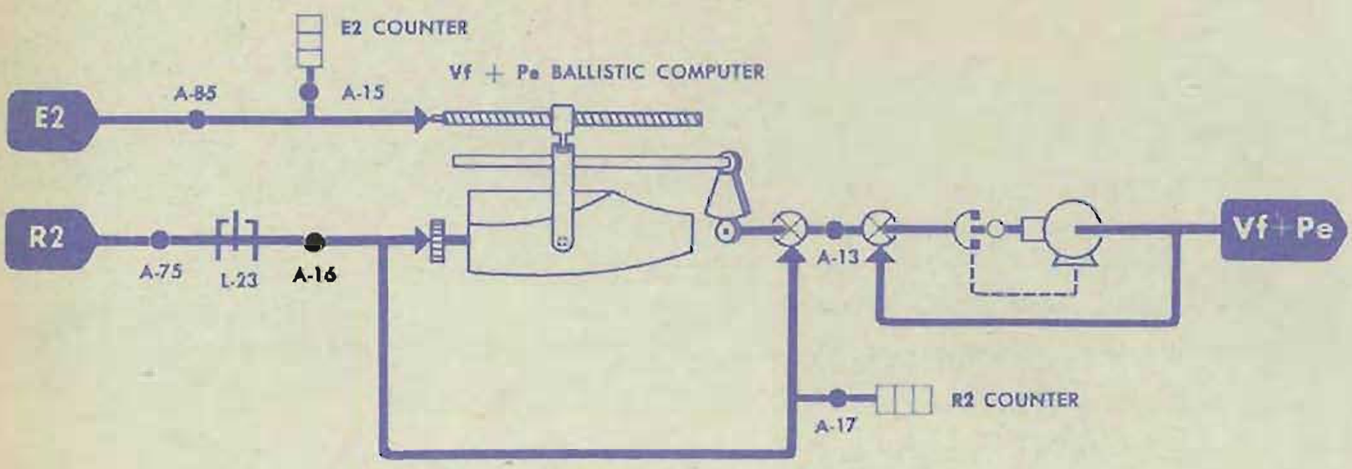
Adjustment

If the *R2* counter does not read the proper values, loosen A-16.

Turn the *R2* counter gearing until the limits are correct. Tighten A-16 and recheck.

Readjust A-75.

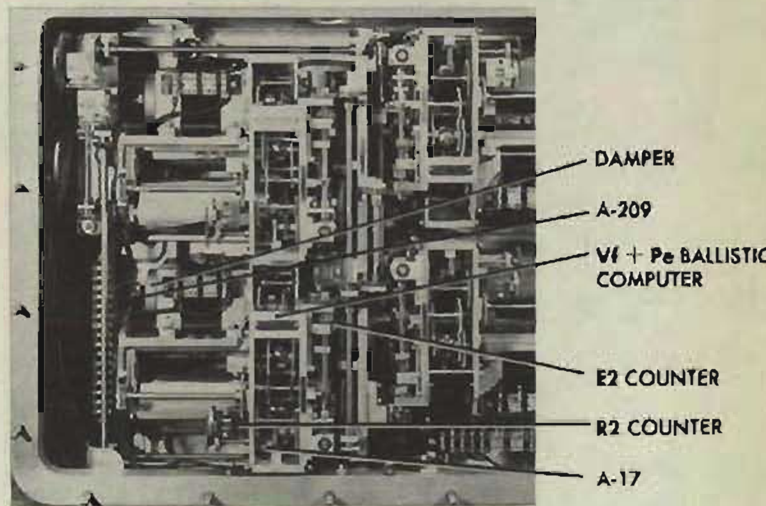
Check A-13.



A-17 R2 COUNTER to Vf + Pe BALLISTIC COMPUTER

Location

A-17 is under cover 4, in the *Vf + Pe* ballistic computer.



Check

Turn the power OFF.
Set *E2* and *R2* at the values listed on the legend plate.

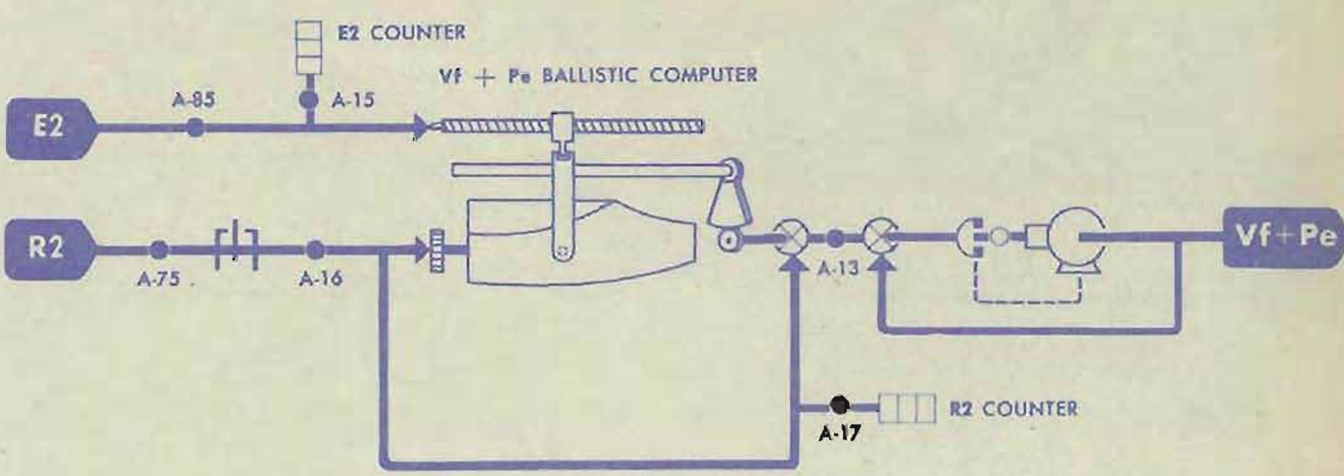
Loosen A-209 on the *Vf + Pe* follow-up damper, and push the damper to the end of the shaft.

Insert a 3/16-inch setting rod through the casting, follower arm, and cam. If it is necessary to change the *R2* input to insert the setting rod, A-17 is upset and should be readjusted.

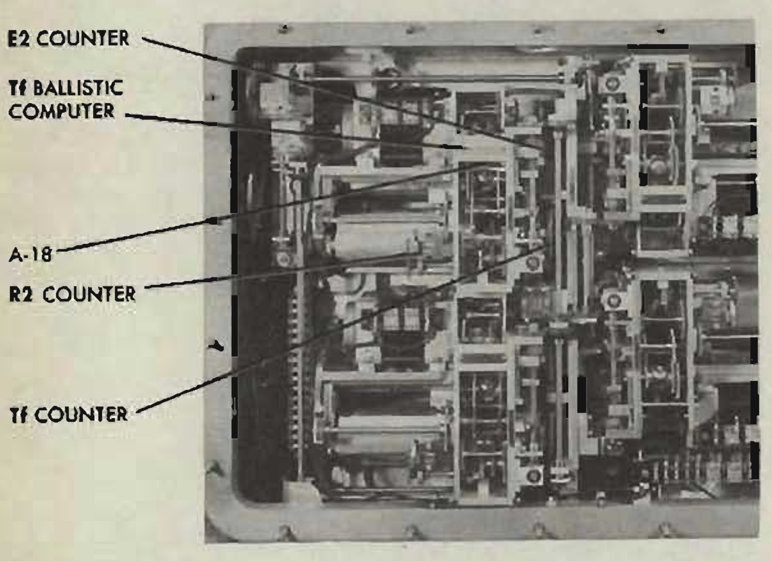
Adjustment

With the setting rod inserted, loosen A-17. Turn the *R2* counter gearing until the counter reads the value specified on the legend plate.

Tighten A-17 and recheck.
Remove the setting rod.
Replace the damper on the follow-up and tighten A-209.
Check A-16, A-75, and A-13.



A-18 SYNCHRONIZING THE Tf FOLLOW-UP



Location

A-18 is under cover 4, in the *Tf* ballistic computer.

Check

Refer to the N.I.O. final test sheet for the particular unit being checked.

Turn the power ON.

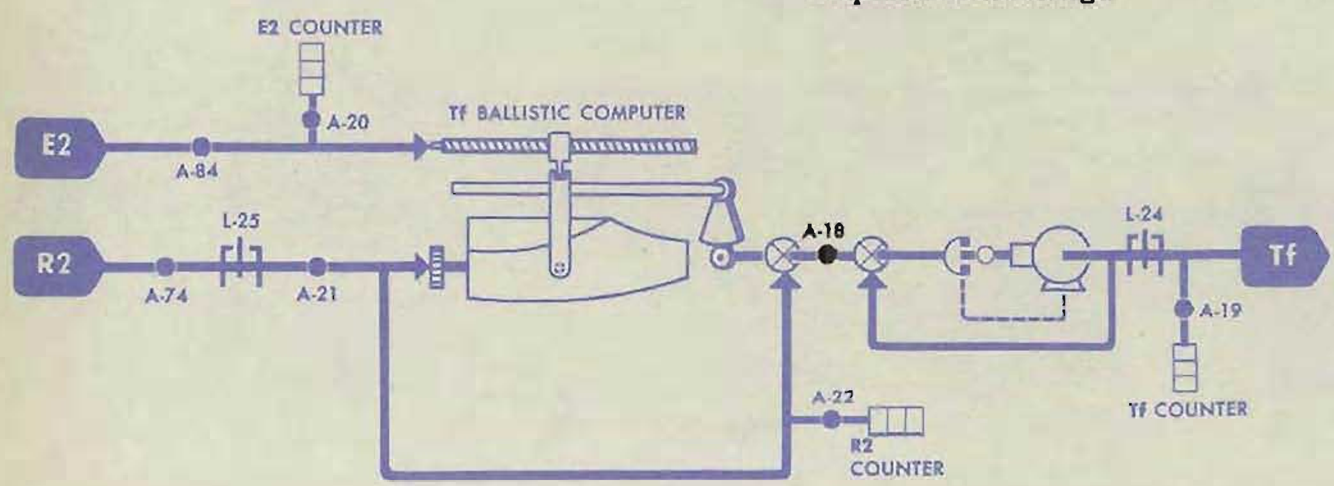
Set *E2* and *R2* at the values given on the N.I.O. final test sheet.

Read the *Tf* unit counter and note any variation from the corresponding values recorded on the test sheet. If the *Tf* value is *consistently less* or *consistently greater* than the recorded value, A-18 is in error and should be readjusted.

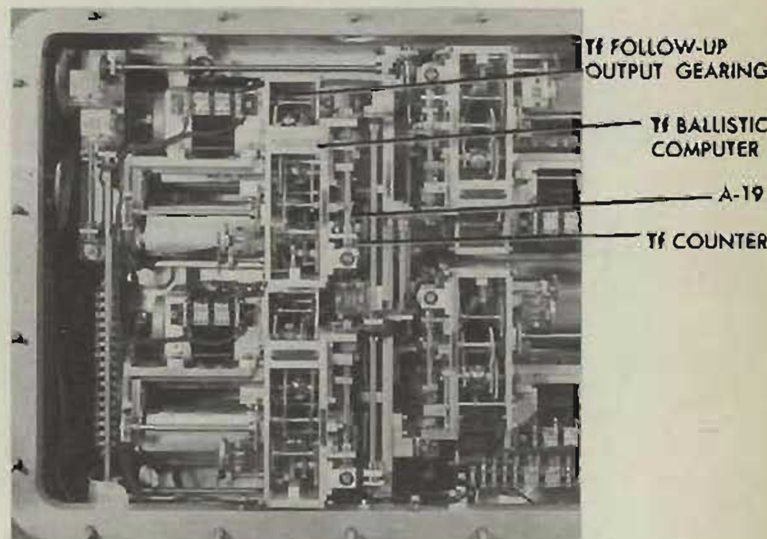
Adjustment

Loosen A-18. Turn the gear on which it is mounted to synchronize the follow-up at the correct value of *Tf*. Tighten A-18.

Refer to the N.I.O. acceptance test sheets and run the complete test of the *Tf* ballistic computer. If necessary, A-18 may be readjusted slightly to improve the readings.



A-19 Tf COUNTER to L-24



Location

A-19 and L-24 are under cover 4, in the *Tf* ballistic computer.

Check

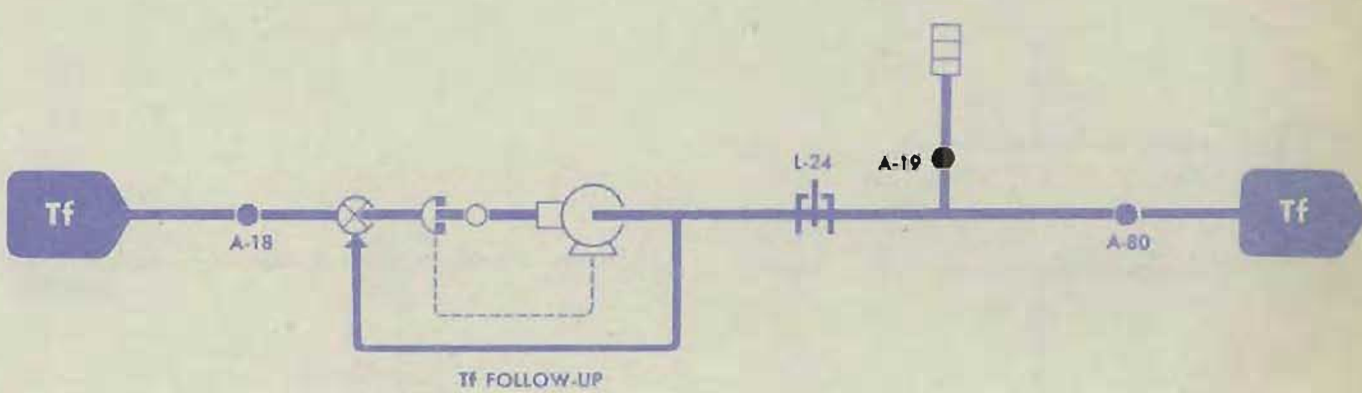
Turn the power OFF.

Turn the *Tf* ballistic computer output gearing from limit to limit.

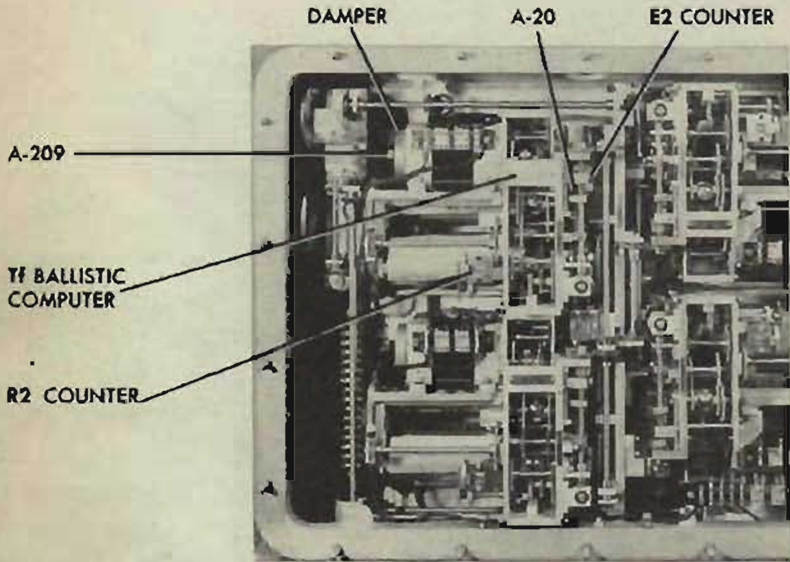
The *Tf* counter should read 0.60 second at the lower limit and 60.60 seconds at the upper limit, on Mods 3, 4, 6, 7, 10, and 13. On Mods 0, 1, 2, and 9, the limits are 1.80 and 61.80 seconds. On Mods 8 and 12, the limits are 0.60 to 50.6 seconds.

Adjustment

Loosen A-19. Slip the counter to the correct reading. Tighten A-19 and recheck. Check A-18 and A-80.



A-20 E2 COUNTER to Tf BALLISTIC COMPUTER



Location

A-20 is under cover 4, in the *Tf* ballistic computer.

Check

Turn the power OFF.
Set *E2* and *R2* at the values listed on the legend plate. Loosen A-209 on the *Tf* follow-up damper, and push the damper to the end of the shaft.
Insert a 3/16-inch setting rod through the casting, the follower arm, and the cam. If it is necessary to change the *E2* input to insert the rod, A-20 is upset and should be readjusted.

Adjustment

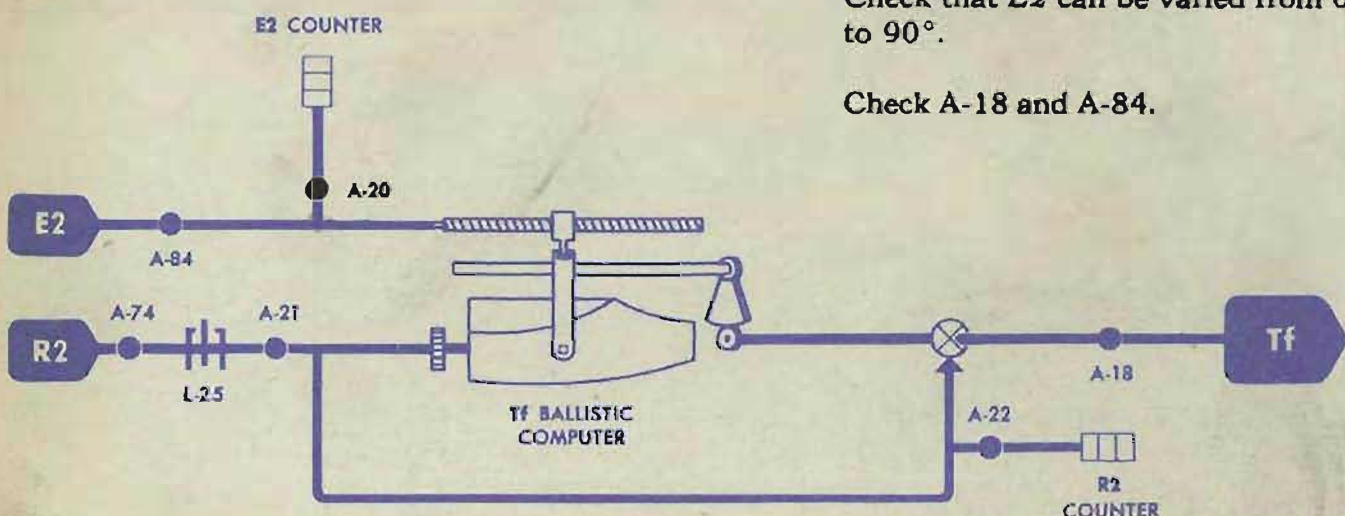
With the setting rod inserted, loosen A-20. Turn the *E2* counter until it reads the value specified on the legend plate. Tighten A-20 and recheck.

Remove the setting rod.

Replace the damper on the follow-up shaft, and tighten A-209.

Check that *E2* can be varied from 0° to 90°.

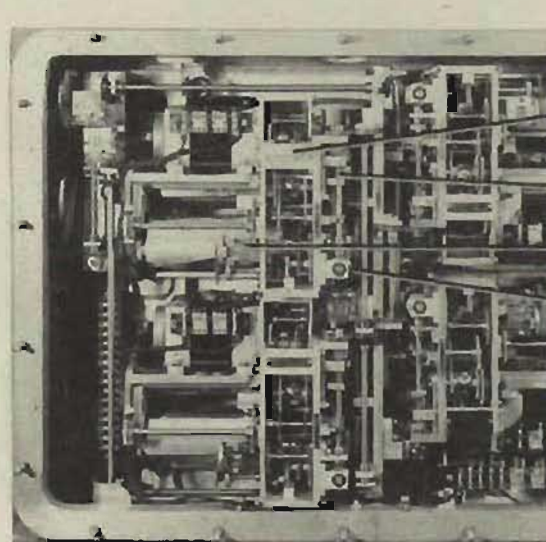
Check A-18 and A-84.



A-21 R2 COUNTER to L-25

Location

A-21 and L-25 are under cover 4, in the *Tf* ballistic computer.



Check

Turn the power OFF.
Loosen A-74, and readjust later.
Turn the *R2* input to the *Tf* ballistic computer from limit to limit.
The *R2* counter should read 300 yards at the lower limit and 18,200 yards at the upper limit, on Mods 3, 4, 6, 7, 10, and 13. On Mods 0, 1, 2, and 9, the limits are 1,300 and 18,200 yards. On Mods 8 and 12, the limits are 300 and 20,200 yards.

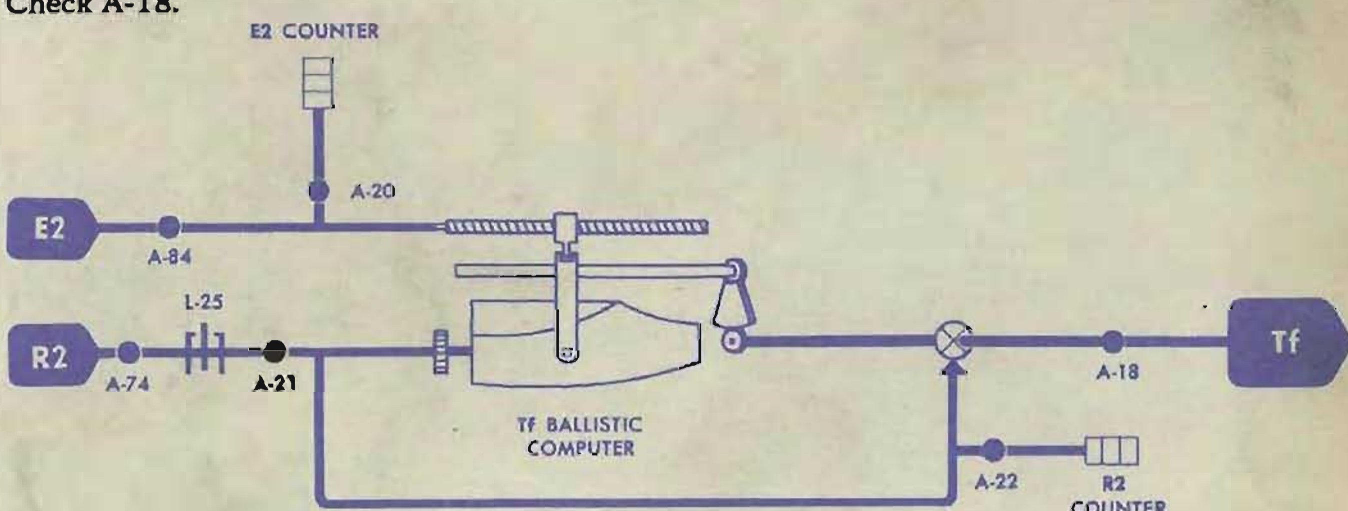
Adjustment

If the *R2* counter does not read the proper value, loosen A-21.

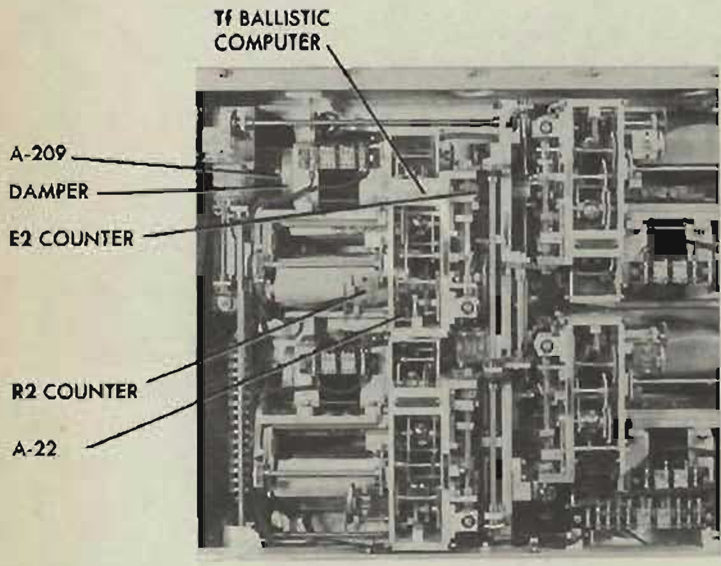
Turn the *R2* counter gearing until the limits are correct. Tighten A-21 and recheck.

Readjust A-74.

Check A-18.



A-22 R2 COUNTER to Tf BALLISTIC COMPUTER



Location

A-22 is under cover 4, in the *Tf* ballistic computer.

Check

Turn the power OFF.

Set *E2* and *R2* at the values listed on the legend plate.

Loosen A-209 on the *Tf* follow-up damper, and push the damper to the end of the shaft.

Insert a 3/16-inch setting rod through the casting, the follower arm, and the cam. If it is necessary to change the *R2* input to insert the rod, A-22 is upset, and should be readjusted.

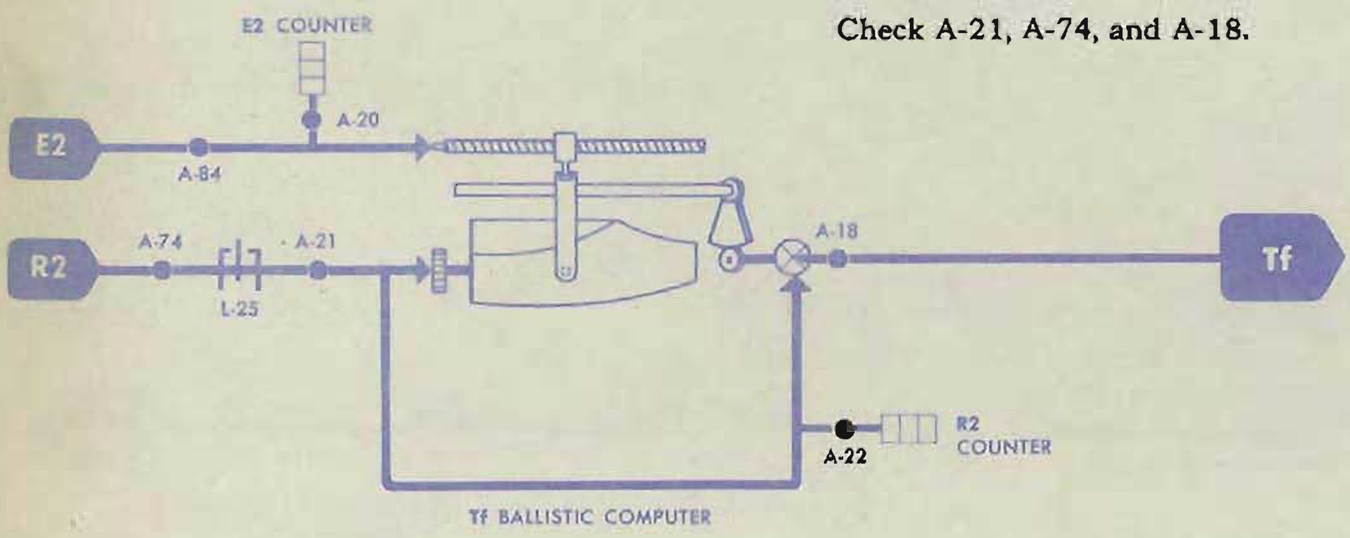
Adjustment

With the setting rod inserted, loosen A-22. Turn the *R2* counter until it reads the value specified on the legend plate. Tighten A-22 and recheck.

Remove the setting rod.

Replace the damper on the follow-up, and tighten A-209.

Check A-21, A-74, and A-18.



A-28 DECK TILT COMPONENT SOLVER to L DIALS

Location

A-28 is under cover 6 directly behind the *L* dials.

Check

Remove leads 1B and 1BB from the *Dd* follow-up. Turn the follow-up output gearing to set *Dd* at 0°, and wedge the line.

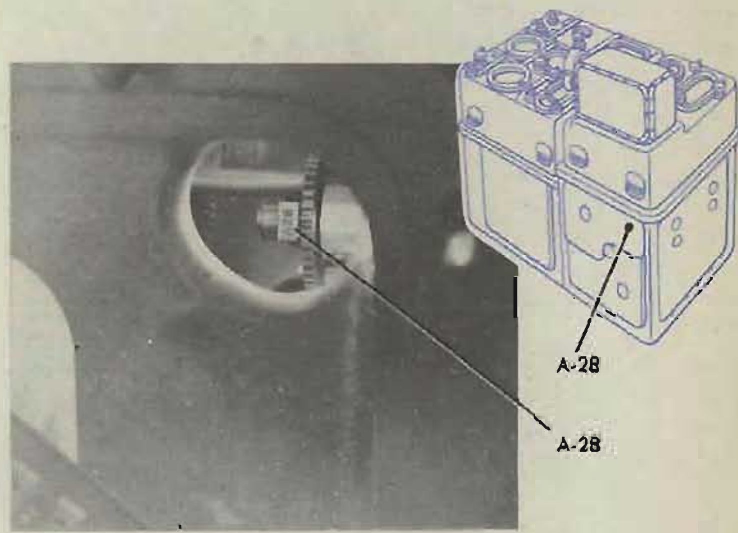
Turn the power ON. Turn the control switch to LOCAL.

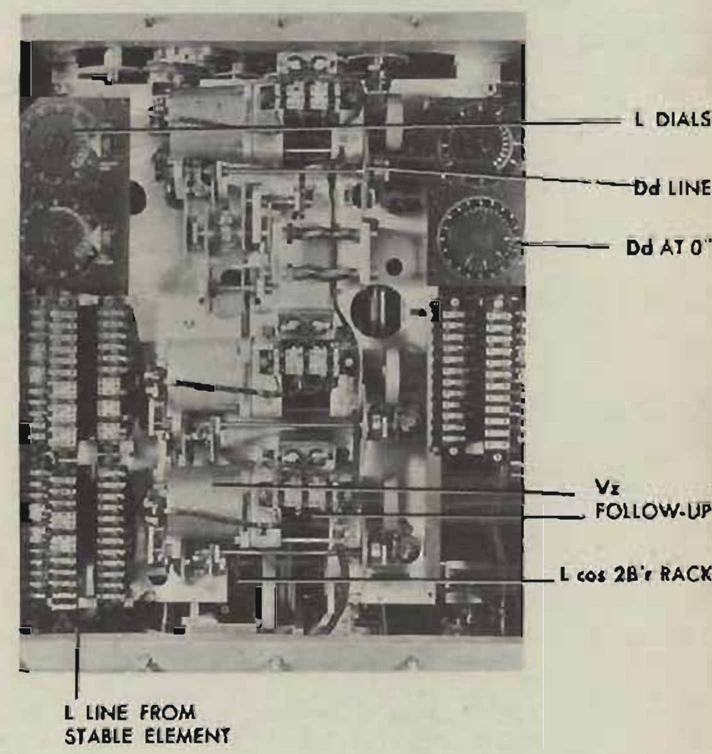
Set *L* at 2000′.

Use the generated bearing crank in the OUT position to set *B′r* at 0°, as read on the *B′gr* dial.

Set up a dial indicator to measure motion of the *L* cos 2*B′r* rack of the deck tilt component solver. This rack, which moves vertically, is accessible under cover 7, below the *Vz* follow-up, about four inches in.

Observe the indicator while turning *B′r* from 0° to 180°. The indicator reading should not change during the rotation of the vector gear. In most cases, however, it is inadvisable to readjust A-28 unless the total indicator movement exceeds 0.002 inch.

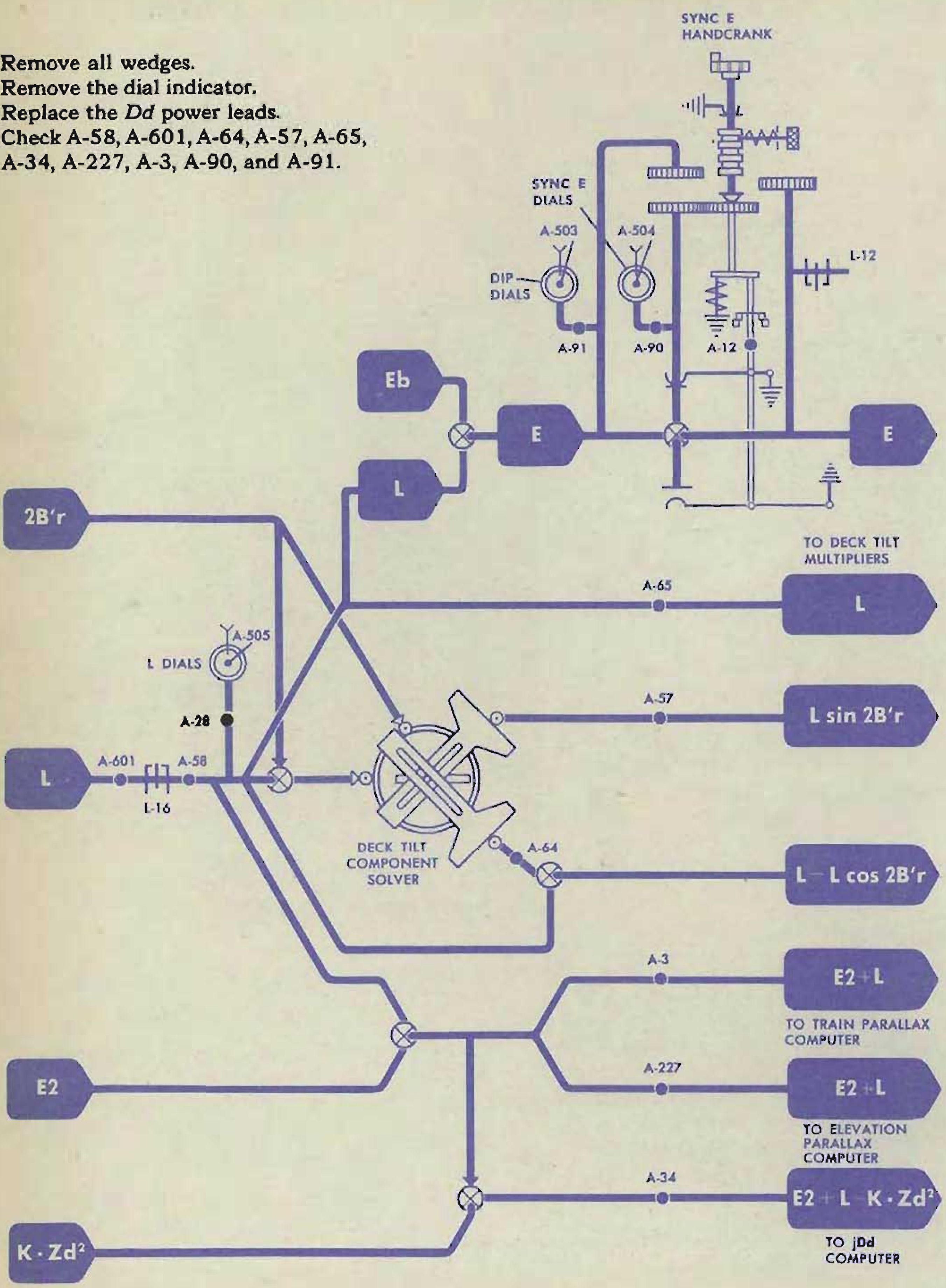




Adjustment

Make A-28 slip tight.
Set *B′r* at 45° and note the reading of the dial indicator.
Turn *B′r* from 45° to 0°. Then turn the *L* shaft line until the indicator has its original reading. Hold the *L* shaft line and bring the computer *L* dials to 2000′ by turning the square mounting plate behind the dials. Tighten A-28 and recheck.
Turn the the power OFF.

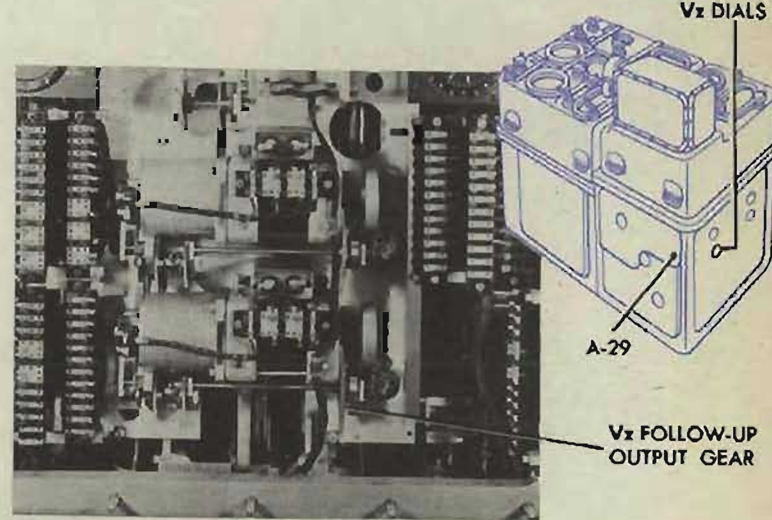
Remove all wedges.
Remove the dial indicator.
Replace the *Dd* power leads.
Check A-58, A-601, A-64, A-57, A-65, A-34, A-227, A-3, A-90, and A-91.

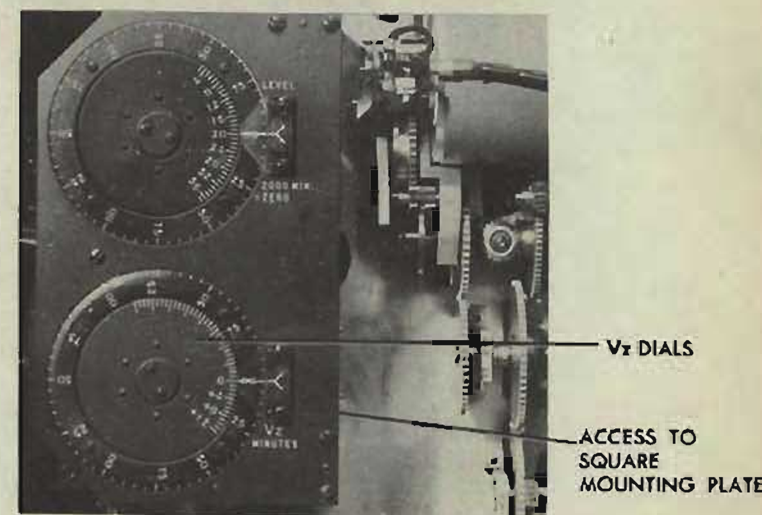


A-29 Vz DIALS to L-34

Location

A-29 is under cover 6, on the shaft to the *Vz* dials. It is reached through an access hole in the upper right corner. L-34 can be seen under cover 7, near the output of the *Vz* follow-up. It is mounted in a vertical position with the upper limit of *Vz*, +1860′, at the top, and the lower limit of *Vz*, −2940′, at the bottom.





Check

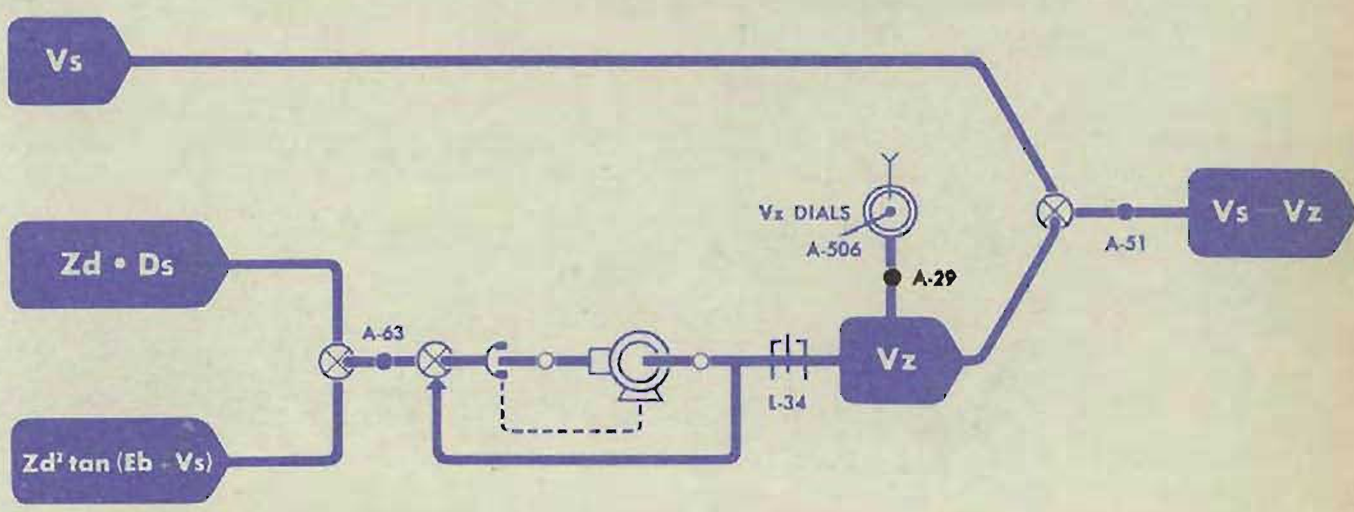
Turn the power OFF.

Turn the *Vz* follow-up output gearing until the lower limit of L-34 is reached.
The *Vz* dials should read −2940′.

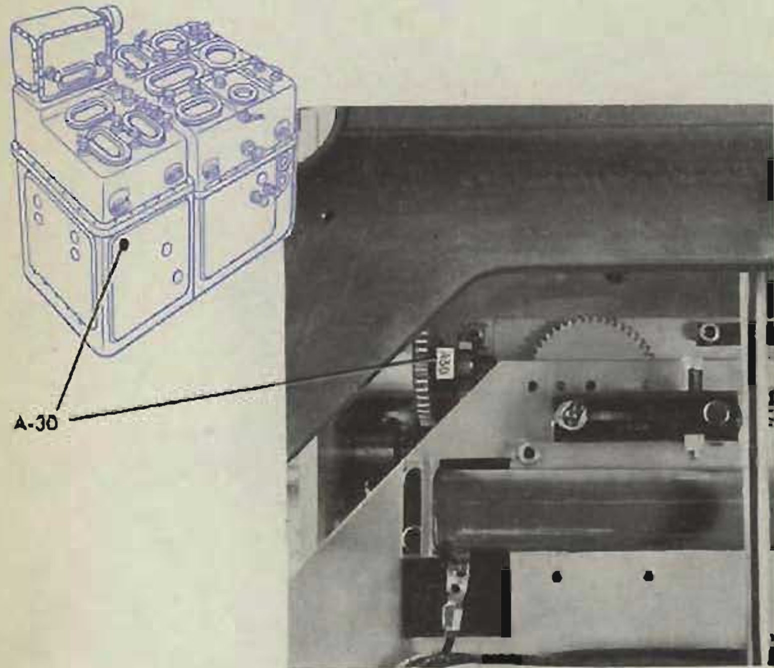
Turn the follow-up output gearing until the upper limit of L-34 is reached.
The *Vz* dials should read +1860′.

Adjustment

If the limits are not correct, make A-29 slip-tight. Hold the stop at one limit and slip the dials to the proper reading by turning the square mounting plate behind the dials. Tighten A-29 and recheck at the other limit. Check A-63 and A-51.



A-30 Zd DIALS to L-17



Location

A-30 is under cover 8, directly behind the *Zd* dials.

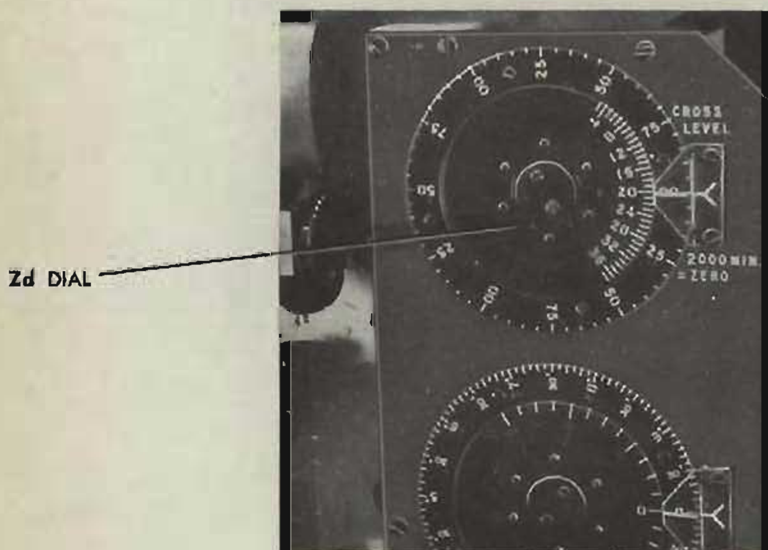
L-17 is located under cover 7, on the rear deck plate about 12 inches in. The upper limit is toward the left of the computer.

Check

Loosen A-603.
Turn the *Zd* shaft line to run L-17 from one limit to the other.
The *Zd* dials should read 480′ at the lower limit and 3520′ at the upper limit.

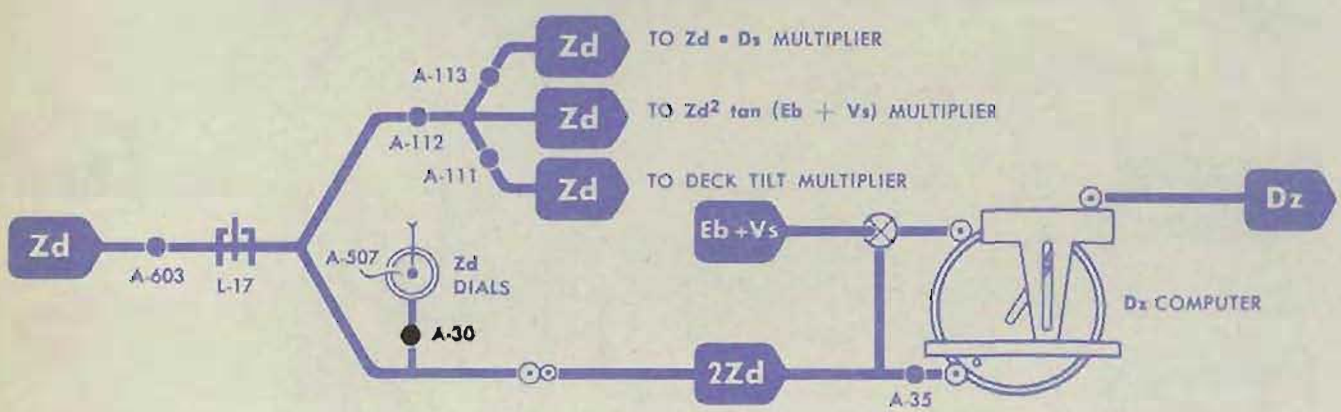
IMPORTANT

If either limit cannot be reached, it is possible that A-112, A-35, A-113, or A-111 is in error.
Determine which clamp is in error and loosen it.



Adjustment

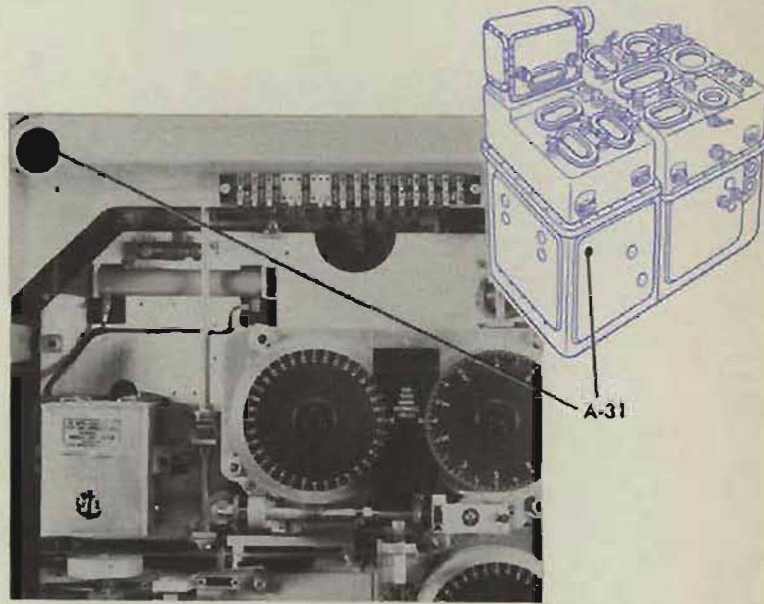
If the *Zd* dials do not show their proper values at the stop limits, make A-30 slip-tight.
Set the *Zd* dials at their proper reading by holding the *Zd* input against the stop and turning the square mounting plate behind the *Zd* dials.
Tighten A-30 and recheck by running *Zd* to the other limit.
Readjust A-603 and any other clamps loosened.
Check A-112, A-35, A-113 and A-111.



A-31 Dd DIALS to L-32

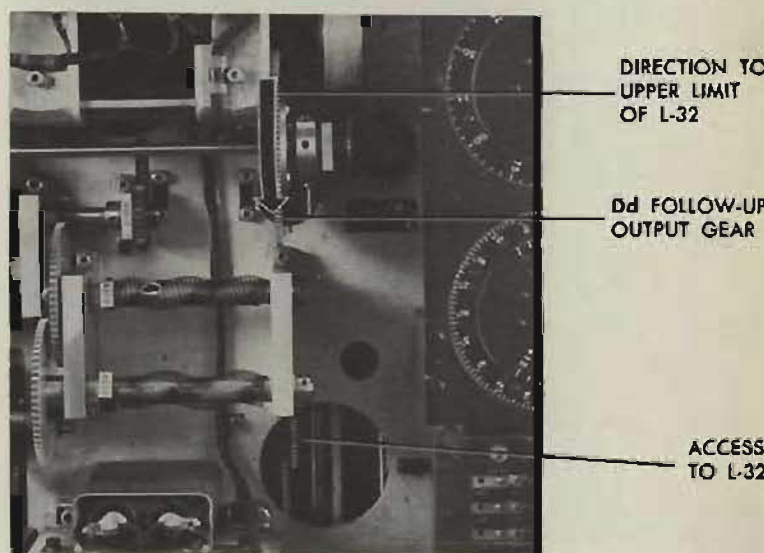
Location

A-31 is under cover 8, on the *Dd* dial group shaft behind the *Dd* dials.
L-32 can be seen through a 2-inch hole above the damper of the *jB'r* follow-up motor. The upper limit is toward the left of the computer.



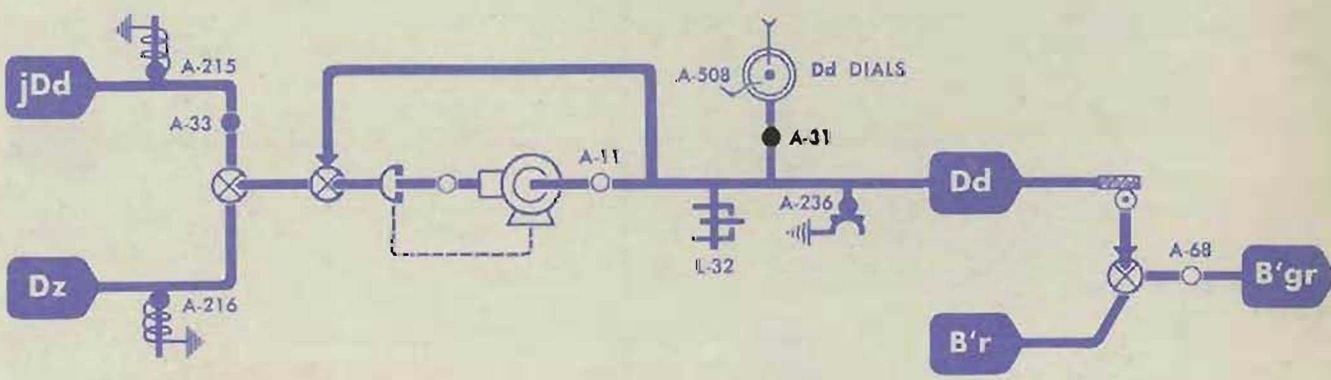
Check

Turn the power OFF.
Turn the *Dd* follow-up output gear until the upper limit of L-32 is reached. The *Dd* dials should read +120°.
Turn the gear in the opposite direction to reach the lower limit of L-32. The *Dd* dials should read −120°.

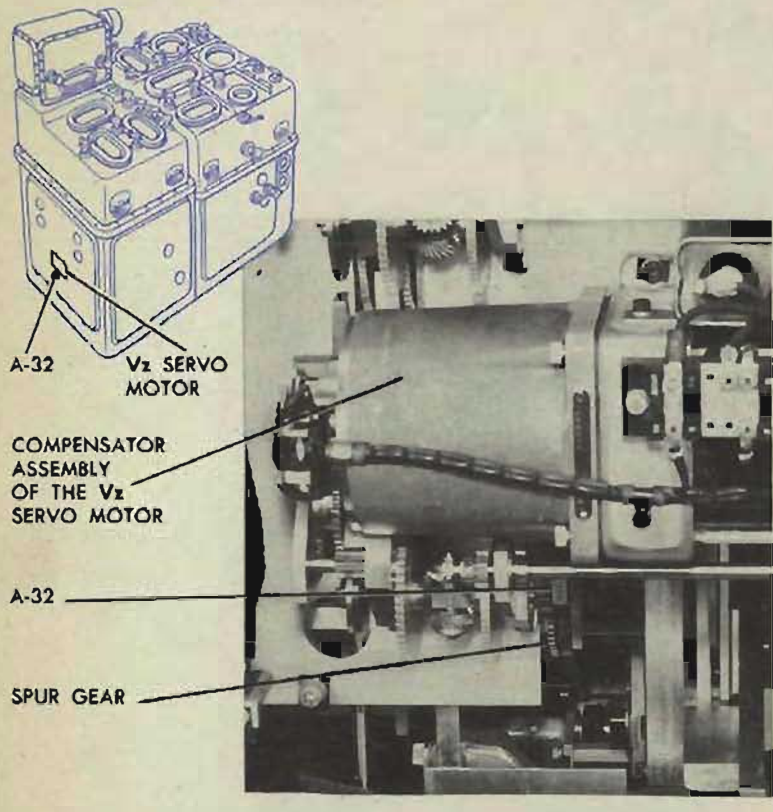


Adjustment

If the *Dd* dials do not read the correct values, hold the stop against one limit, loosen A-31, and set the dials at the proper value.
Tighten A-31 and recheck by turning the *Dd* follow-up output gear until the other limit is reached.
Split any overtravel.
Check A-68 and A-33.



A-32 Zd^2 tan (Eb+Vs) MULTIPLIER to Eb+Vs LINE



Note

A-112, A-113, A-208, and A-63 should be checked before readjusting A-32.

Location

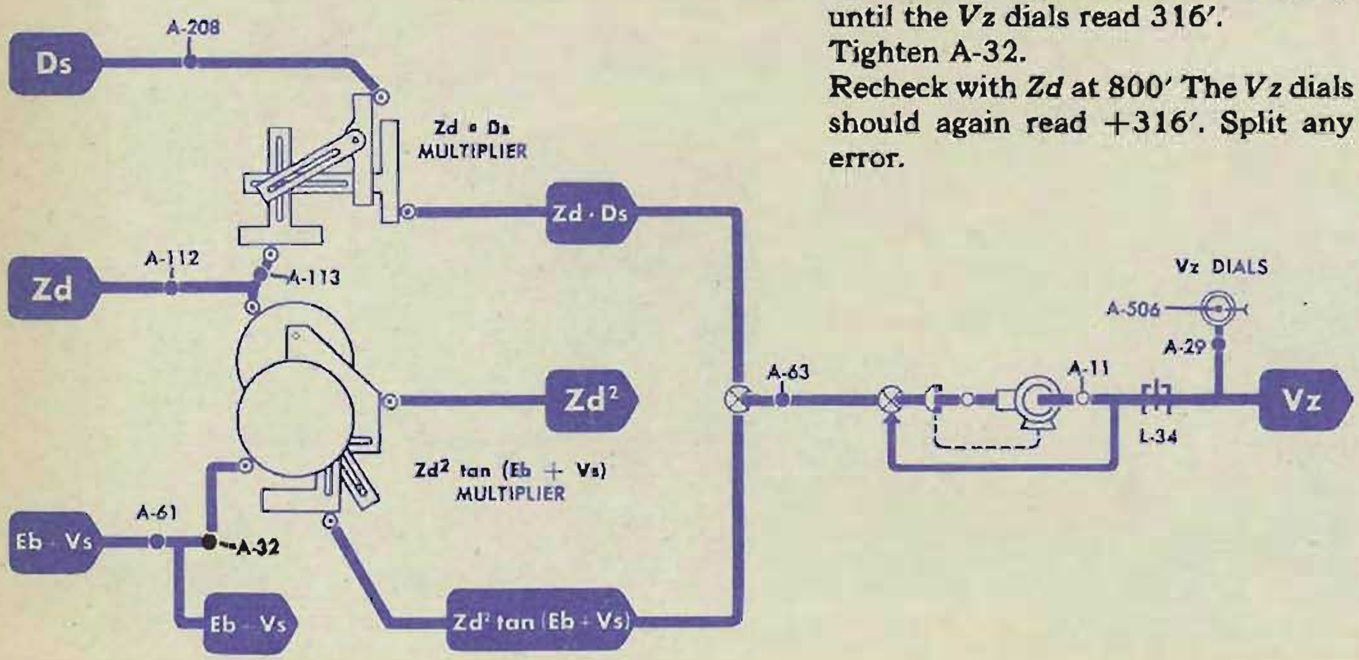
A-32 is under cover 7, below the compensator assembly on the *Vz* servo motor.

Check

Turn the power ON to energize the *Vz* follow-up.
Set *L* at 2000′.
Set *E* at 60° with the sync *E* handcrank at CENTER; then pull the handcrank OUT and match the sync *E* dials at the fixed index.
Set *Vs* at 2000′.
Set *Ds* at 500 mils.
Set *Zd* at 3200′.
The *Vz* dials should read +316′.

Adjustment

If the *Vz* dials do not read +316′, make A-32 slip-tight.
Turn the spur gear next to the clamp until the *Vz* dials read 316′.
Tighten A-32.
Recheck with *Zd* at 800′ The *Vz* dials should again read +316′. Split any error.



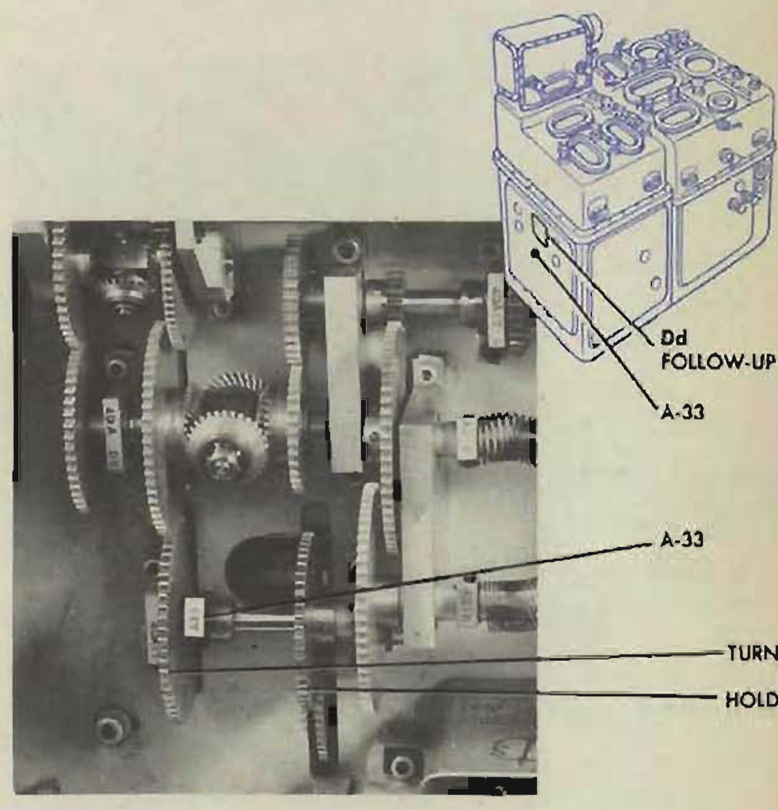
A-33 SYNCHRONIZING THE Dd FOLLOW-UP

Note

A-31 should be checked before readjusting A-33.

Location

A-33 is under cover 7, below the compensator assembly on the *Dd* follow-up.

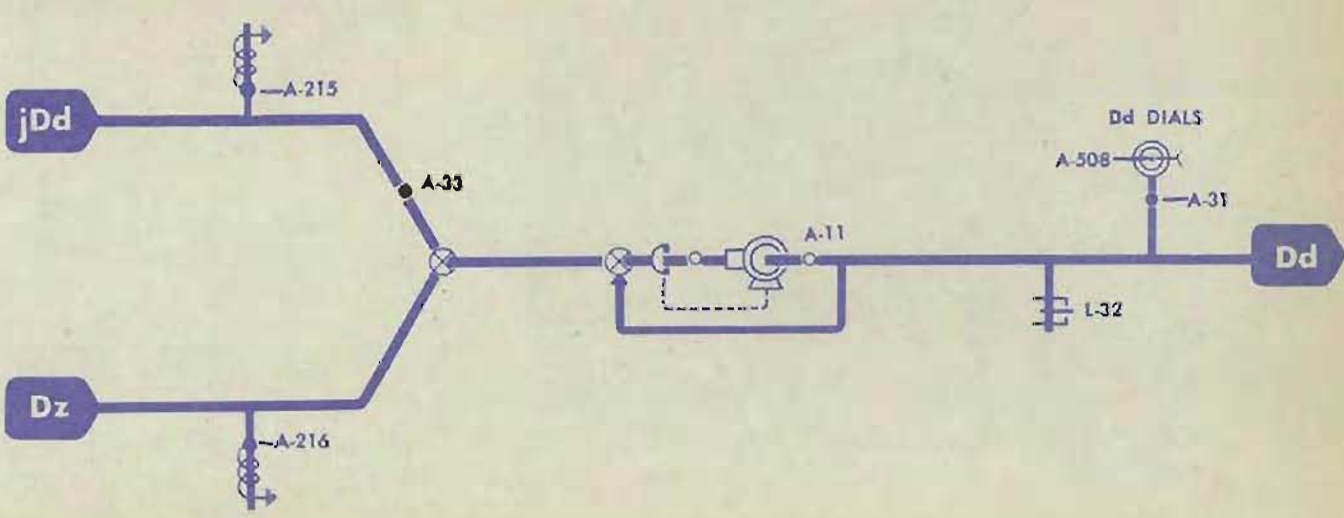


Check

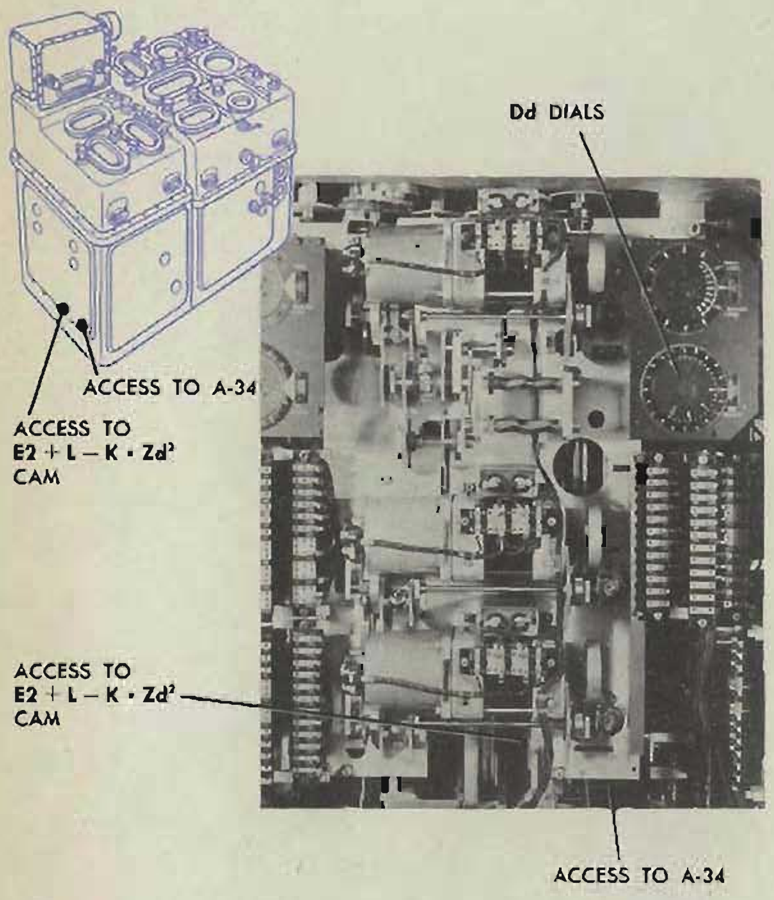
Turn the power ON to energize the *Dd* follow-up.
Set *Ds* at 500 mils.
Set *Vs* at 2000′.
Set *L* at 2000′.
Set *Zd* at 2000′.
Set *E2* at 0°.
Set *Eb* at 0°.
The *Dd* dials should read 0°.

Adjustment

If the *Dd* dials do not read 0°, make A-33 slip-tight.
Turn the spur gear next to A-33 until the *Dd* dials read 0°.
Tighten A-33 and recheck.



A-34 jDd COMPUTER to E2+L-K·Zd² LINE



Location

A-34 is under cover 7. It is reached through an access at the lower right.

Check

Turn the power ON to energize the *Dd* follow-up motor.
Set *L* at 2000′.
Set *Zd* at 2000′.
Set *Ds* at 750 mils.
Set *E2* at 60°.
The *Dd* dials should read +30°00′.

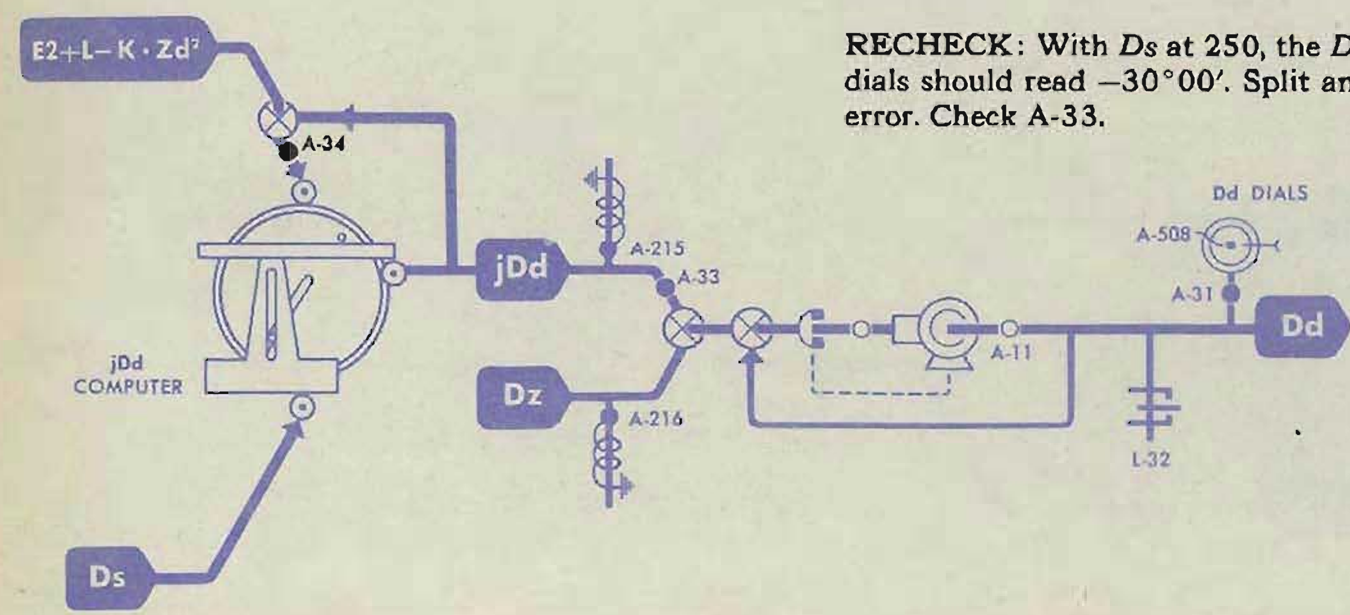
Adjustment

If the *Dd* dials do not read +30°00′, make A-34 slip-tight.

Turn the *E2+L—K·Zd²* cam until the *Dd* dials read +30°00′.

Tighten A-34 and recheck.

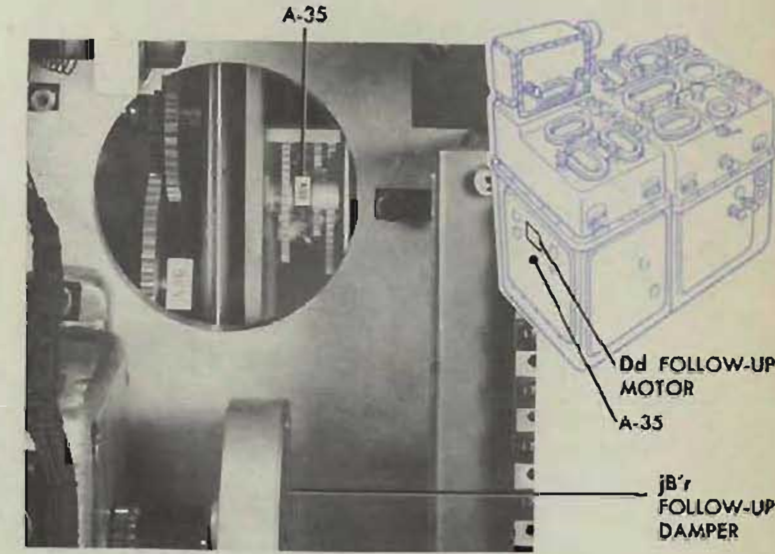
RECHECK: With *Ds* at 250, the *Dd* dials should read −30°00′. Split any error. Check A-33.



A-35 Dz COMPUTER to Zd DIALS

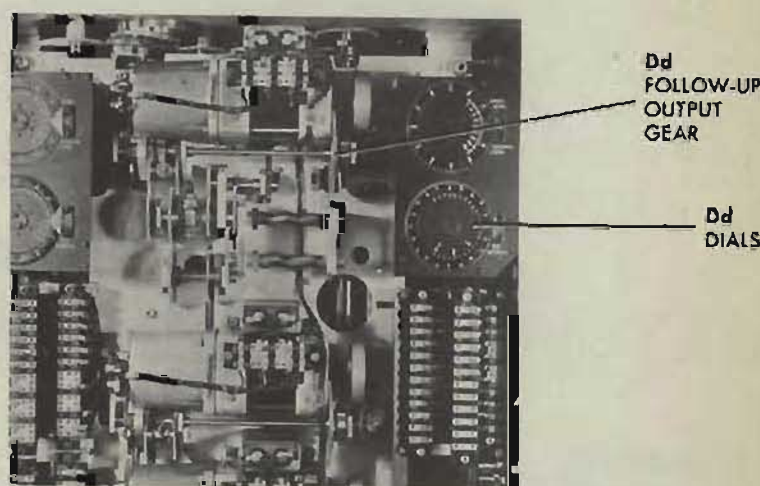
Location

A-35 is under cover 7. It can be reached through a hole above the damper on the *jB'r* follow-up.



Check

Turn the power ON.
Set *Ds* at 500 mils.
Set *Vs* at 2000'.
Set *L* at 2000'.
Set *Zd* at 2000'.
Turn the *Eb* line, using the sync *E* handcrank in the OUT position.
Full travel of the *Eb* line should cause no movement of the output rack of the *Dz* computer.
Mark the *Dd* follow-up output gear for use as an indicator to check for any motion of the *Dz* output rack.



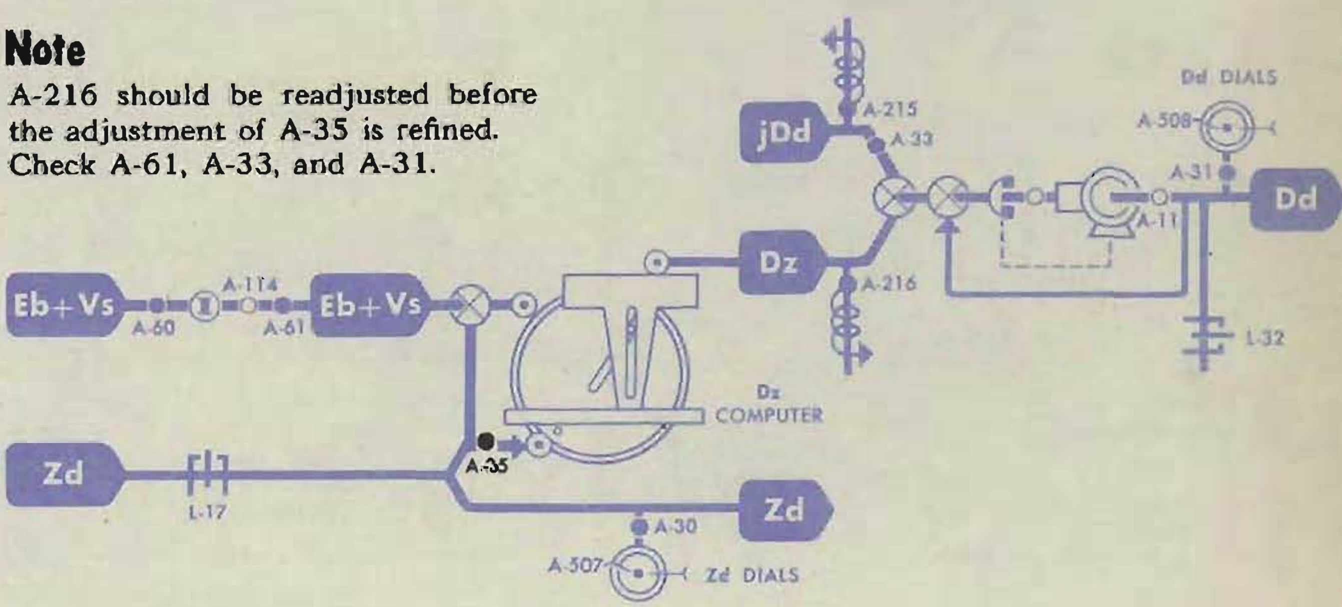
Adjustment

If there is any motion of the *Dd* follow-up output gearing, slip-tighten A-35. Adjust the slot in the vector gear to a horizontal or zero position by turning the vector gear with a gear pusher. At the zero position there will be no movement of the *Dd* follow-up output gearing for full travel of the *Eb* line.

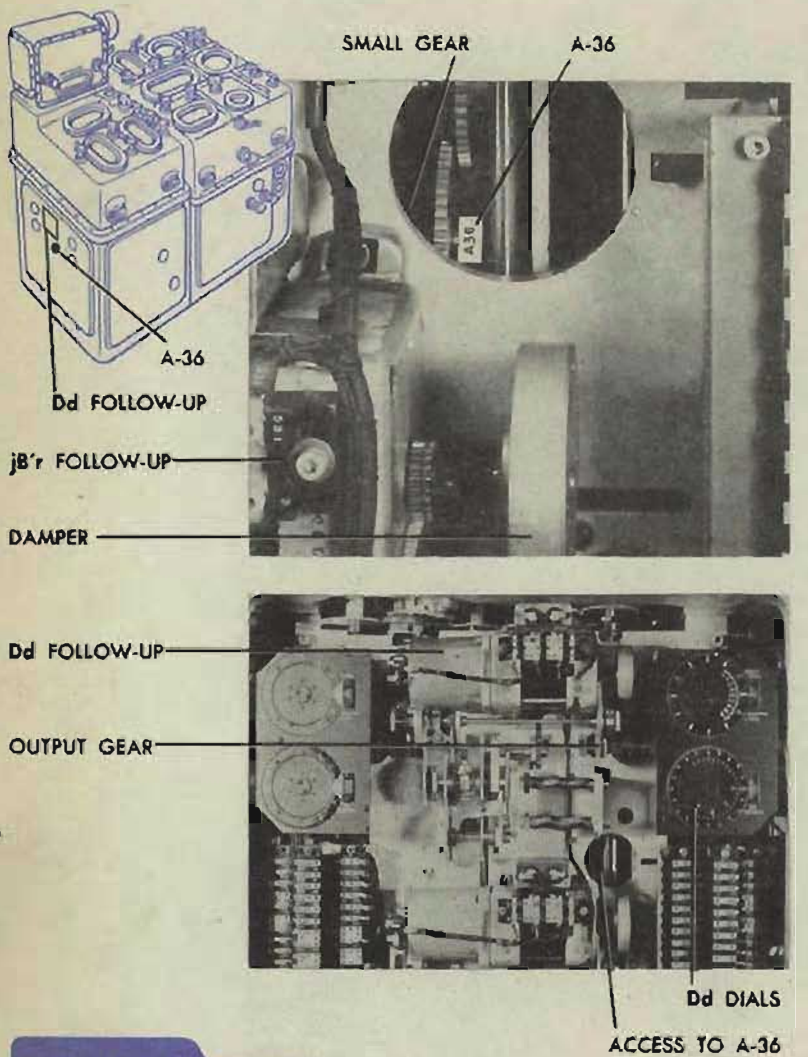
WARNING: After each adjustment of the vector gear, check that *Zd* has not moved off 2000'.

Note

A-216 should be readjusted before the adjustment of A-35 is refined. Check A-61, A-33, and A-31.



A-36 jDd COMPUTER to Ds COUNTER



Location

A-36 is under cover 7. It is reached through a hole above the damper of the *jB'r* follow-up motor.

Check

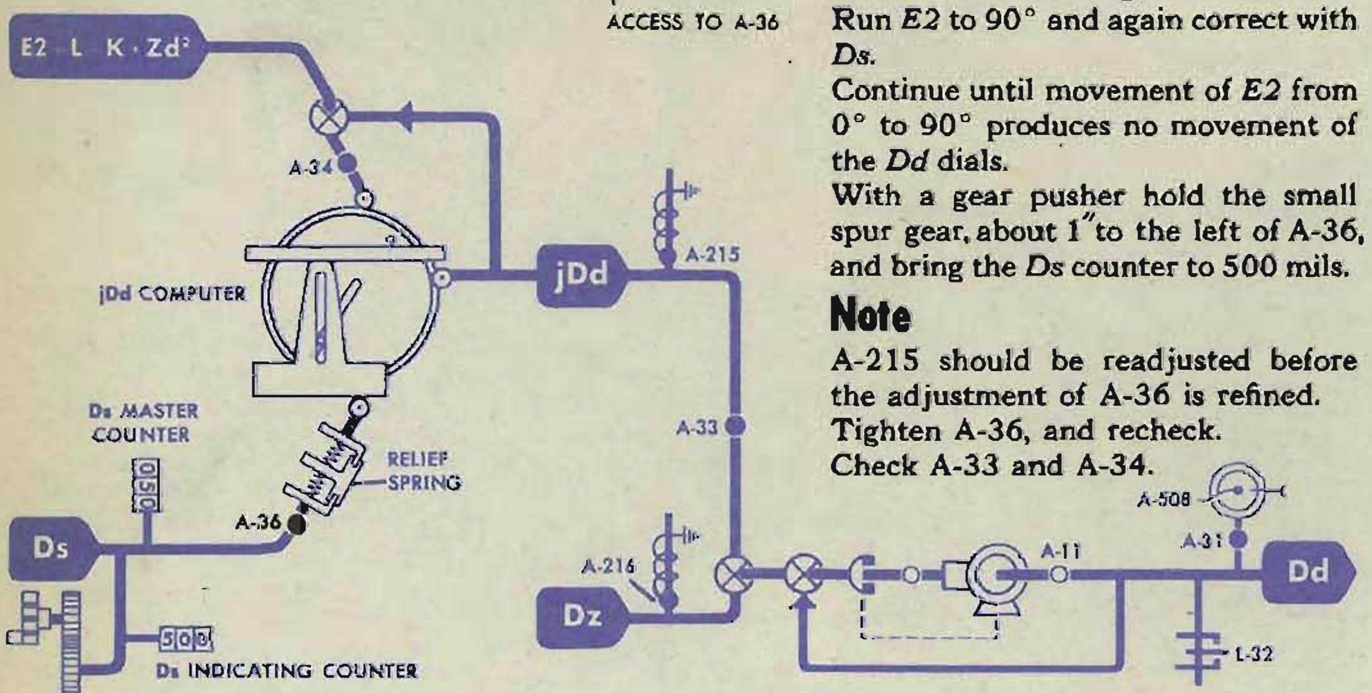
Turn the power ON.
Set *Ds* at 500 mils.
Set *L* at 2000′.
Set *Zd* at 2000′.
The *Ds* input rack should be at a position where full travel of *E2* will cause no motion of the *jDd* output gear.
Any motion of the *jDd* output gear is indicated by movement of the *Dd* follow-up output gearing.

Adjustment

The *jDd* computer is unusual in that the vector gear is the output. If there is any movement of the *Dd* follow-up output gearing, make A-36 slip-tight. Adjust the input rack to the zero position as follows:
Set *E2* at 0°.
Note the reading of the *Dd* dials.
Run *E2* to 90°.
Turn the *Ds* handcrank to bring the *Dd* dials back to the same value noted when *E2* was at zero.
Run *E2* back to zero.
Note the new reading of the *Dd* dials.
Run *E2* to 90° and again correct with *Ds*.
Continue until movement of *E2* from 0° to 90° produces no movement of the *Dd* dials.
With a gear pusher hold the small spur gear, about 1″ to the left of A-36, and bring the *Ds* counter to 500 mils.

Note

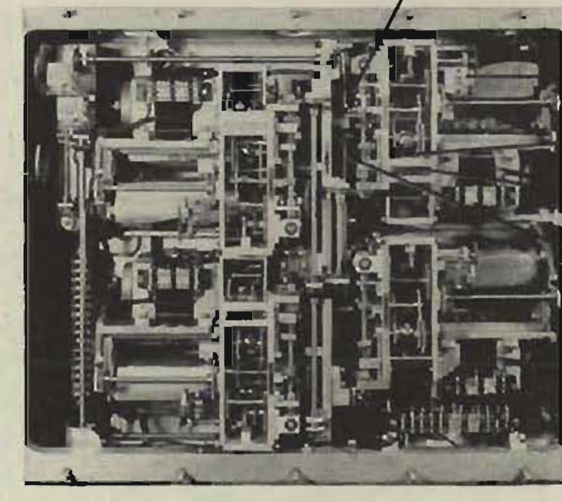
A-215 should be readjusted before the adjustment of A-36 is refined.
Tighten A-36, and recheck.
Check A-33 and A-34.



A-37 SYNCHRONIZING THE Tf/R2 FOLLOW-UP

Location

A-37 is under cover 4, in the *Tf/R2* ballistic computer.



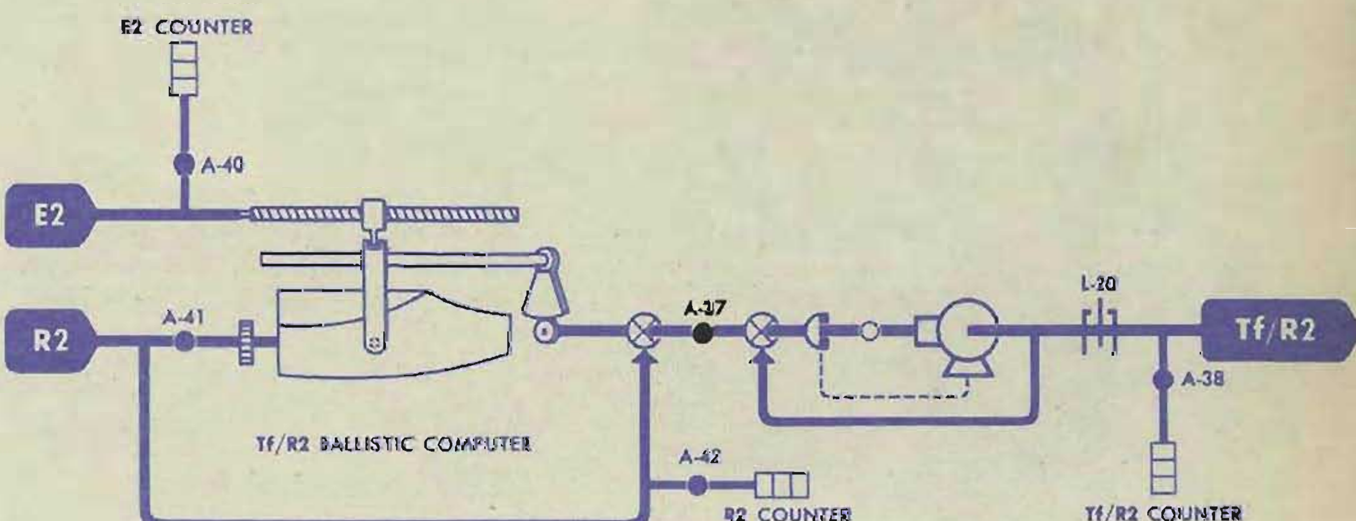
Check

Refer to the N.I.O. final test sheet for the particular unit being checked. Turn the power ON.

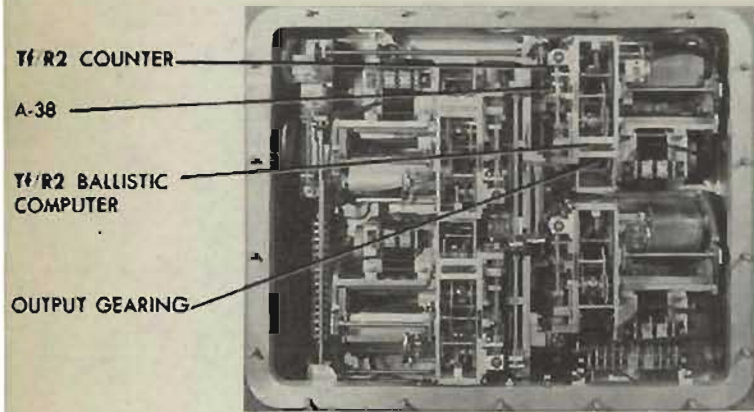
Set *E2* and *R2* (*R2m* on Ser. Nos. 811 and higher) at the values given on the N.I.O. final test sheet.
Read the *Tf/R2* unit counter and note any variation from the corresponding values recorded on the test sheet.
If the *Tf/R2* value is consistently less or consistently greater than the recorded value, A-37 is in error and should be readjusted.

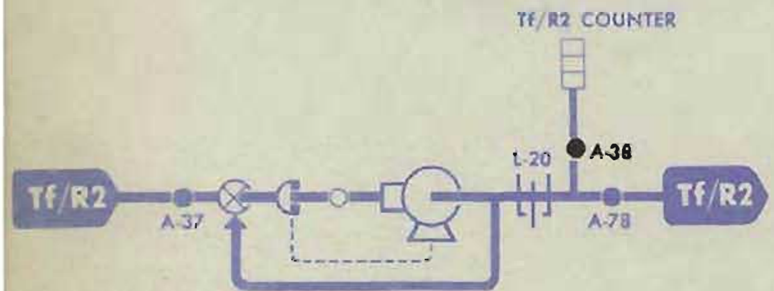
Adjustment

Loosen A-37. Turn the gear on which it is mounted to synchronize the follow-up at the correct value of *Tf/R2*. Tighten A-37. Refer to the N.I.O. final test sheets and run the complete test of the *Tf/R2* ballistic computer. If necessary, A-37 may be readjusted slightly to improve the readings.



A-38 Tf/R2 COUNTER to L-20





Location

A-38 and L-20 are under cover 4, in the *Tf/R2* ballistic computer.

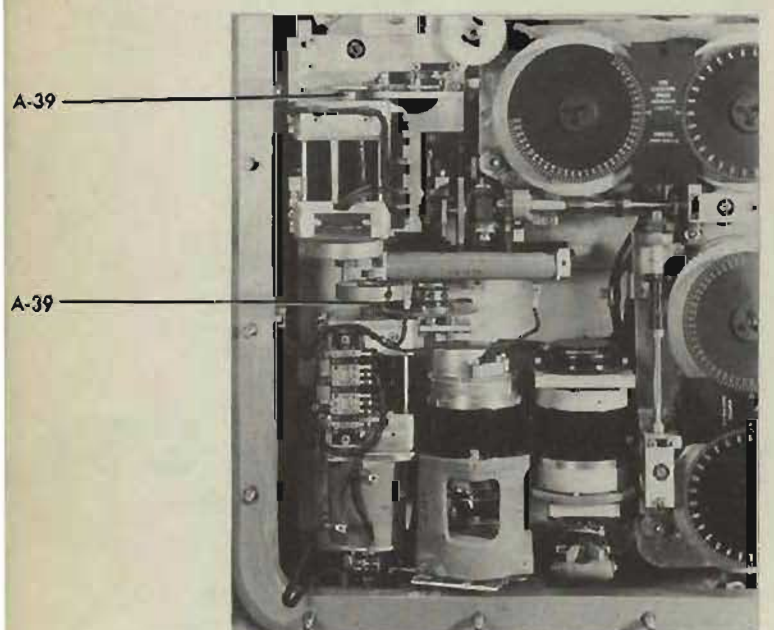
Check

Turn the power OFF.
Turn the *Tf/R2* ballistic computer output gearing from limit to limit.
The *Tf/R2* counter should read 0.00122 at the lower limit and 0.00336 at the upper limit.
On Mods 8 and 12 the limits are 0.001184 to 0.002674.

Adjustment

Loosen A-38. Hold the *Tf/R2* line against the stop and slip the counter to the correct reading.
Tighten A-38 and recheck.
Check A-37 and A-78.

A-39 ASSEMBLY CLAMPS



Location

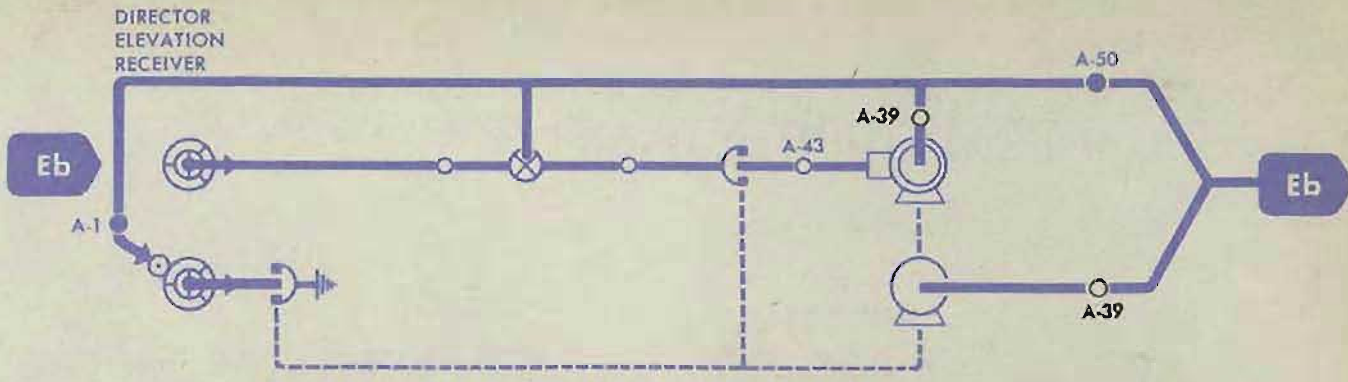
A-39 is under cover 6. There are two clamps numbered A-39, one on each servo motor output shaft of the two *Eb* follow-ups.

Check

If either A-39 is loose, the servo on which it is located may drive without producing any output motion in the computer.

Adjustment

Tighten A-39.



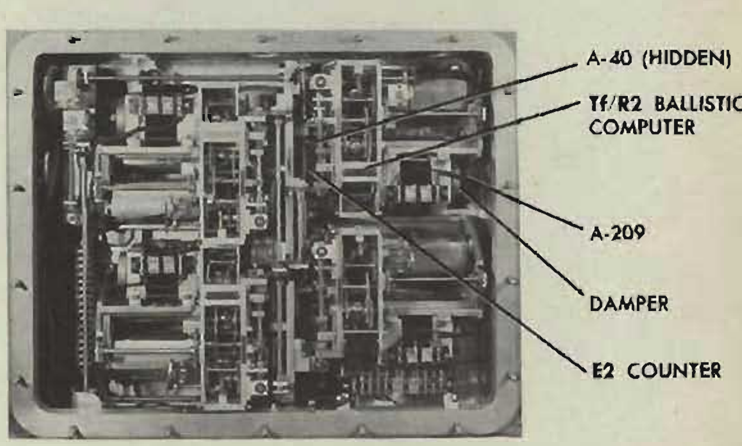
A-40 E2 COUNTER to Tf/R2 BALLISTIC COMPUTER

Location

A-40 is under cover 4, in the *Tf/R2* ballistic computer.

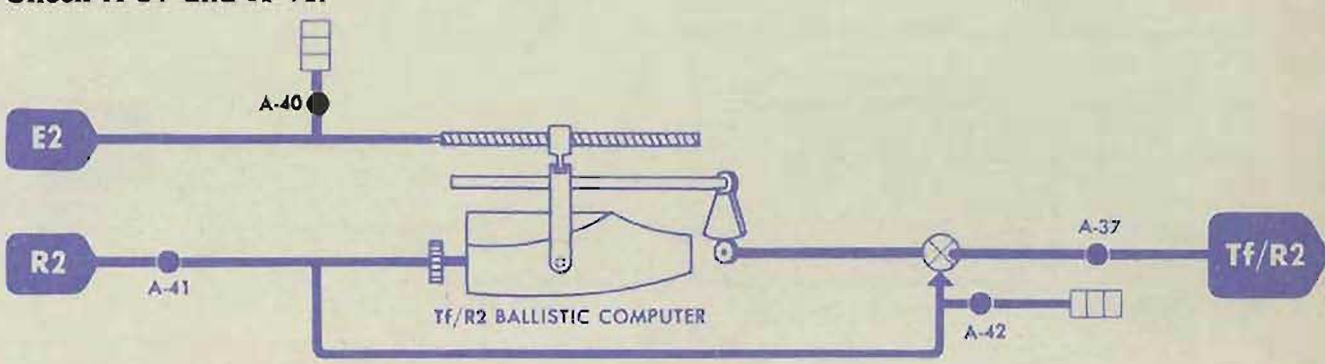
Check

Turn the power OFF.
Set *E2* and *R2* (*R2m* on Ser. Nos. 811 and higher) at the values listed on the legend plate.
Loosen A-209 on the *Tf/R2* follow-up damper, and push the damper to the end of the shaft.
Insert a 3/16-inch setting rod through the casting, the follower arm, and the cam. If it is necessary to change the *E2* input to insert the rod, A-40 is upset and should be readjusted.

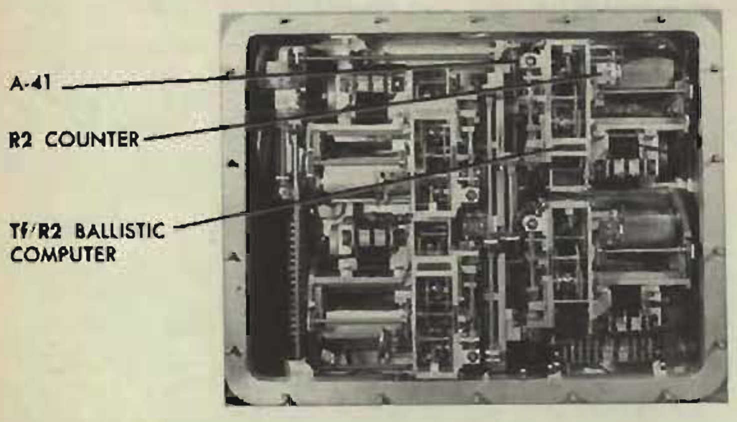


Adjustment

With the setting rod inserted, loosen A-40.
Turn the *E2* counter until it reads the value specified on the legend plate.
Tighten A-40 and recheck.
Remove the setting rod.
Replace the damper on the follow-up shaft and tighten A-209.
Check that *E2* can be varied from 0° to 90°.
Check A-37 and A-41.



A-41 R2 (or R2m) COUNTER to L-21



Location

A-41 and L-21 are under cover 4, in the *Tf/R2* ballistic computer.

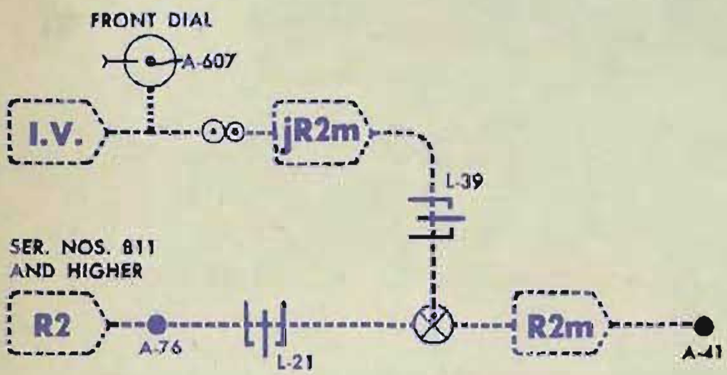
Check

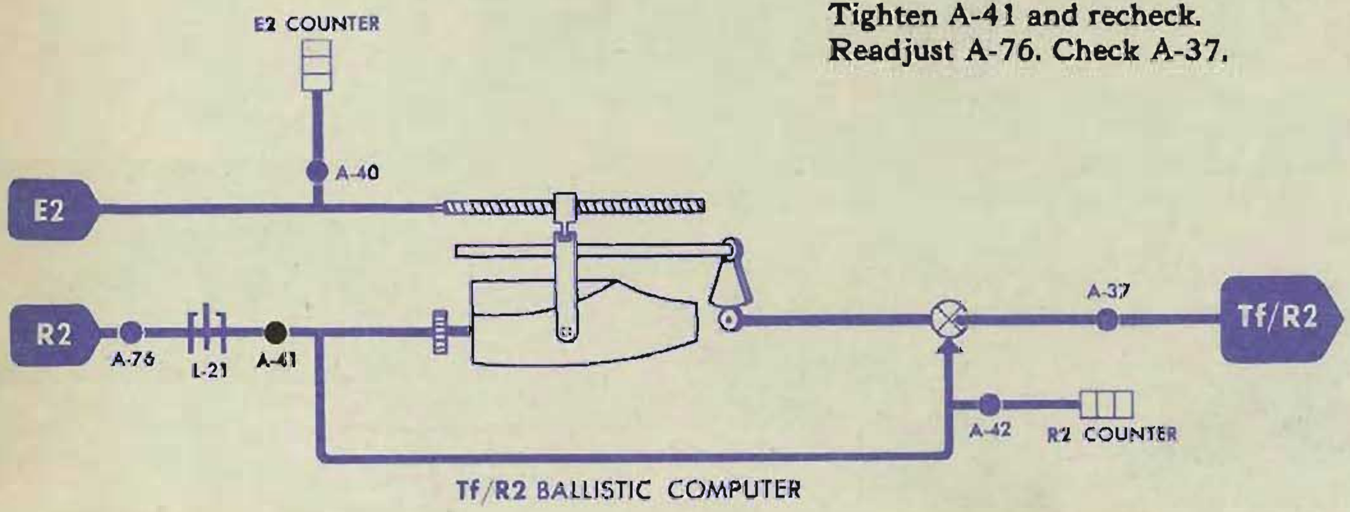
NOTE: In computers with Ser. Nos. 811 and higher, *R2m* is used.

Turn the power OFF.
Set front *I.V.* at 2550 f.s. (Ser. Nos. 811 and higher).
Loosen A-76.
Turn the *R2* (or *R2m*) input to the *Tf/R2* ballistic computer from limit to limit.
The *R2* or *R2m* counter should read 300 yards at the lower limit, and 18,200 yards at the upper limit on Mods 3, 4, 6, 7, 10, and 13. On Mods 0, 1, 2, and 9, the limits are 1,300 and 18,200 yards. On Mods 8 and 12, the limits are 300 and 20,200 yards.

Adjustment

If the *R2* (or *R2m*) counter does not read the proper values, loosen A-41. Hold the line against the stop and turn the counter to the correct value.
Tighten A-41 and recheck.
Readjust A-76. Check A-37.

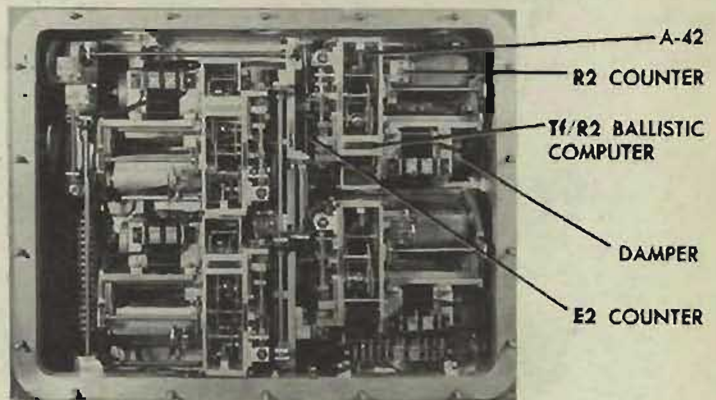




A-42 R2 (or R2m) COUNTER to Tf/R2 BALLISTIC COMPUTER

Location

A-42 is under cover 4, in the *Tf/R2* ballistic computer.



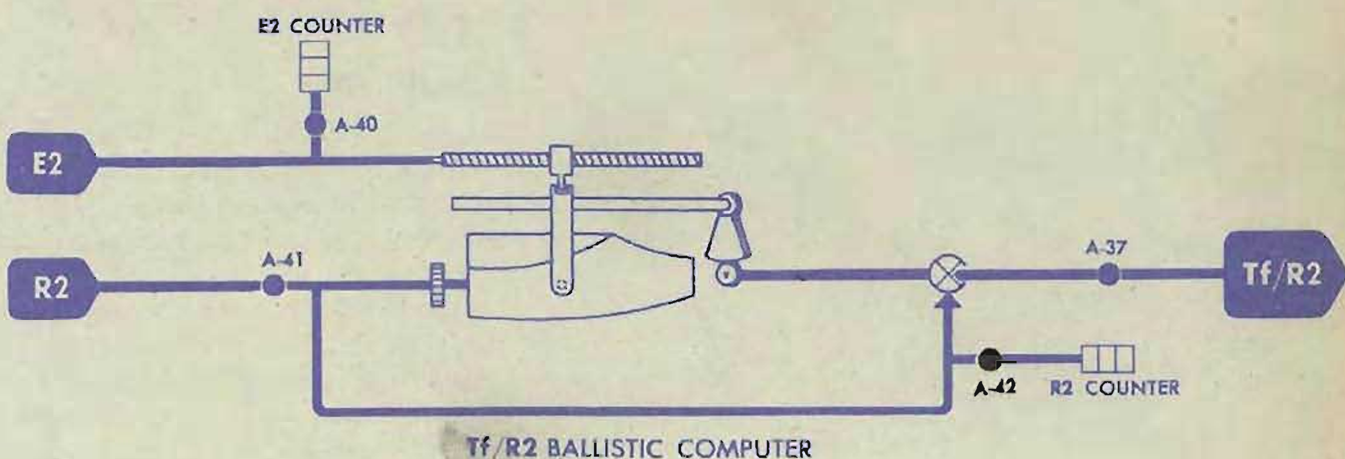
Check

NOTE: In computers with Ser. Nos. 811 and higher, *R2m* is used.

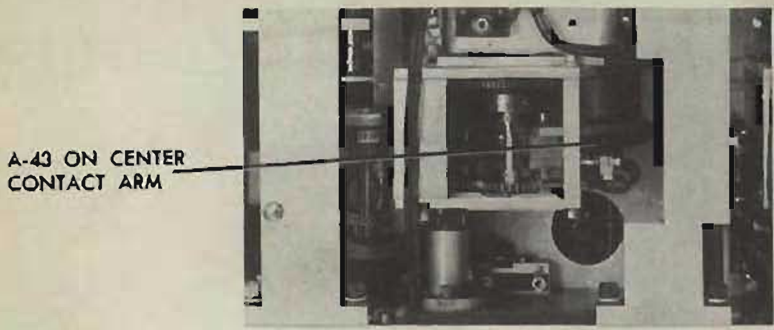
Turn the power OFF.
Set *E2* and *R2* (or *R2m*) at the values listed on the legend plate.
Loosen A-209 on the *Tf/R2* follow-up damper and push the damper to the end of the shaft.
Insert a 3/16-inch setting rod through the casting, the follower arm and the cam.
If it is necessary to change *R2* (or *R2m*) to insert the rod, A-42 is upset and should be readjusted.

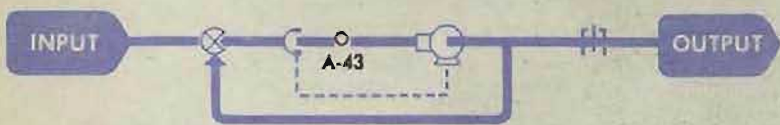
Adjustment

With the setting rod inserted, loosen A-42.
Turn the *R2* (or *R2m*) counter until it reads the value specified on the legend plate.
Tighten A-42 and recheck. Remove the setting rod. Replace the damper on the follow-up, and tighten A-209.
Check A-41, A-37 and A-76.



A-43 ASSEMBLY CLAMPS





Location

There is a small assembly clamp numbered A-43 on the center contact arm of each follow-up.

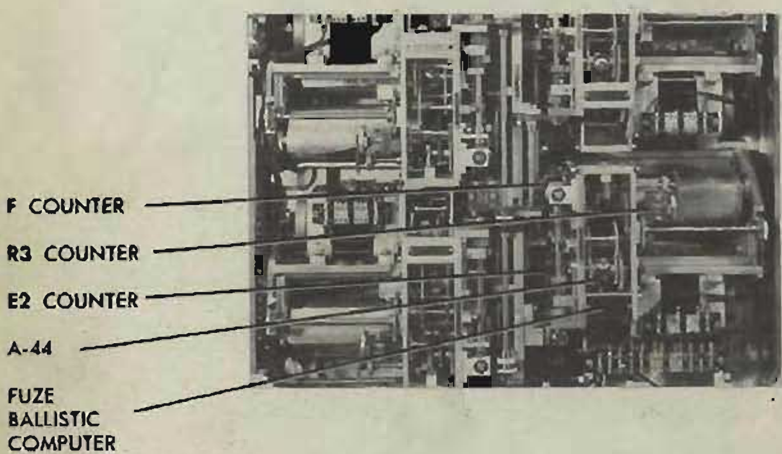
Check

If an A-43 clamp is loose, the follow-up on which it is located may oscillate. See *The Follow-up* in OP 1140A.

Adjustment

Tighten A-43.

A-44 SYNCHRONIZING THE F FOLLOW-UP



Location

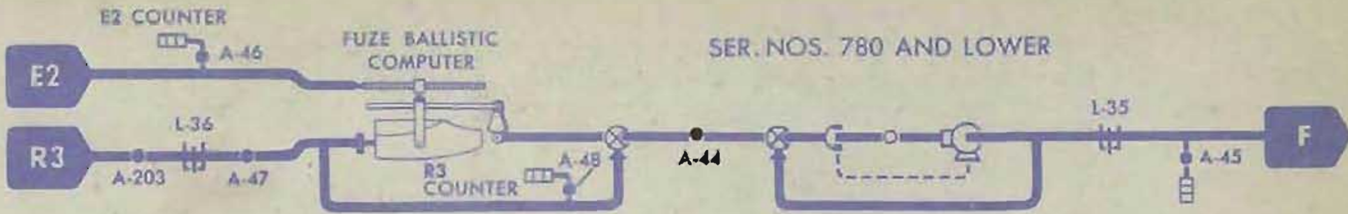
A-44 is under cover 4, in the fuze ballistic computer.

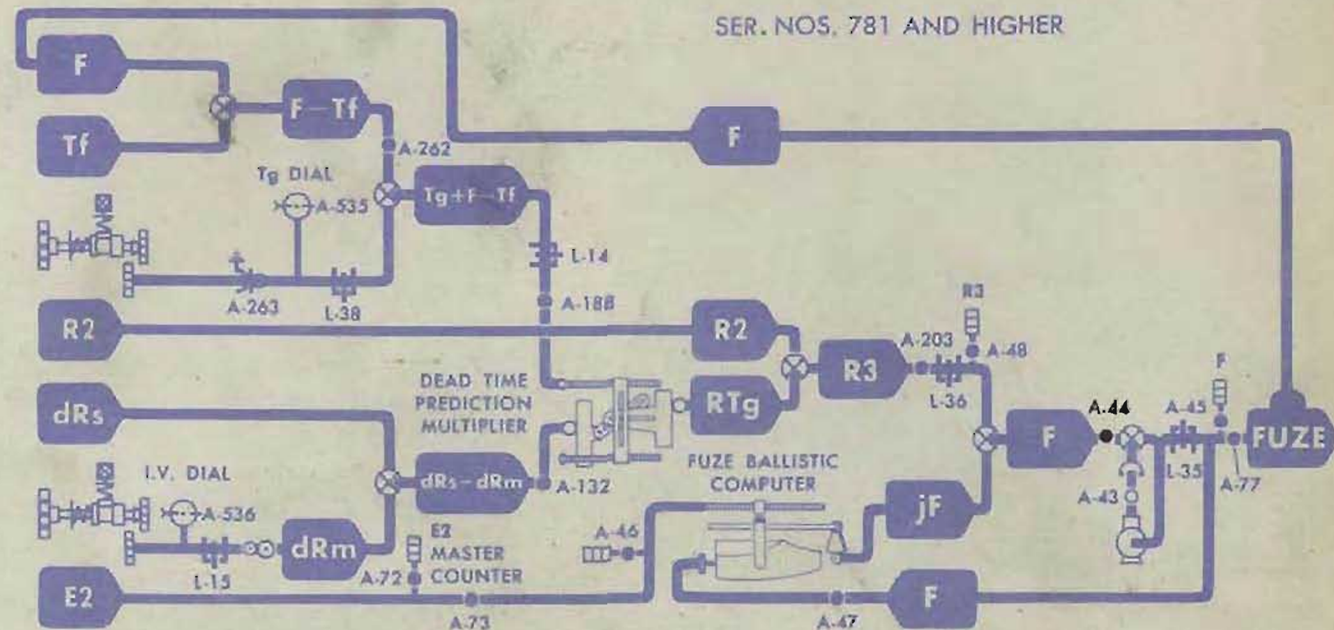
Check

Refer to the N.I.O. final test sheet for the particular unit being checked.
Put the *F* handcrank in the OUT position. Turn the power ON.
Set *E2* and *R3* at the values given on the N.I.O. final test sheet.
Read the *F* unit counter and note any variation from the corresponding values recorded on the test sheet.
On Ser. Nos. 780 and lower, if the *F* value is consistently greater, or consistently less than the recorded value, A-44 is in error and should be readjusted.
On Ser. Nos. 781 and higher, if the error in *F* becomes progressively greater as *R3* is increased, A-44 is in error and should be readjusted.

Adjustment

Loosen A-44. Turn the gear on which it is mounted to synchronize the follow-up at the correct value of *F*. (On Ser. Nos. 781 and higher, make the adjustment while *R3* is set at a high value.) Tighten A-44 and recheck.
Refer to the N.I.O. acceptance test sheets and run the complete test of the fuze ballistic computer. A-44 may be readjusted slightly to improve the readings.

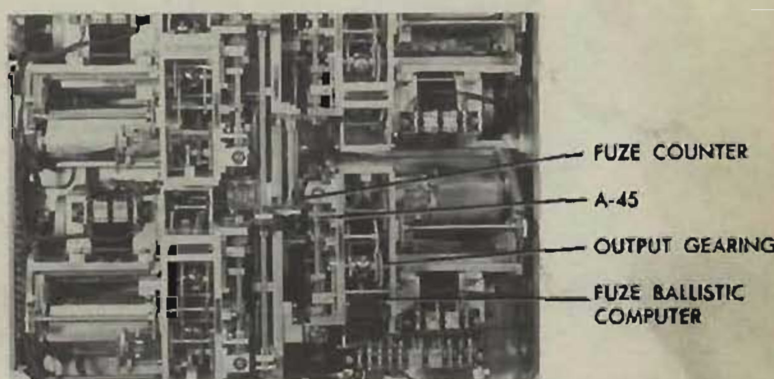




A-45 F COUNTER to L-35

Location

A-45 and L-35 are under cover 4, in the fuze ballistic computer.

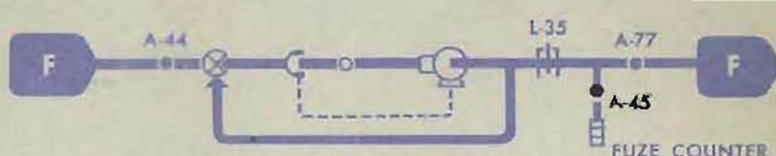


Check

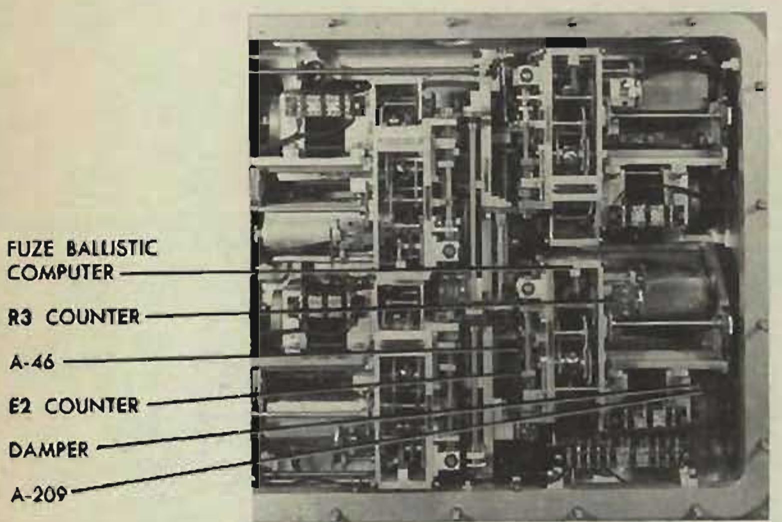
Turn the power OFF.
Turn the fuze ballistic computer output gearing from limit to limit.
The fuze counter should read 0.60 second at the lower limit, and 55.00 seconds at the upper limit on Mods 3, 10, 4, "Univ" 7, and 13. On Mods 0, 2, 1, and 9, the limits are 0.60 and 45.05 seconds. On Mods 6 and "Old" 7, the limits are 0.60 and 45.00 seconds. On Mods 8 and 12, the limits are 0.60 and 49.00 seconds.

Adjustment

If the *F* counter does not read the proper values, loosen A-45. Slip the counter to the correct reading. Tighten A-45 and recheck.
Check A-44 and A-77.
On Ser. Nos. 781 and higher, also check A-47.



A-46 E2 COUNTER to F BALLISTIC COMPUTER



Location

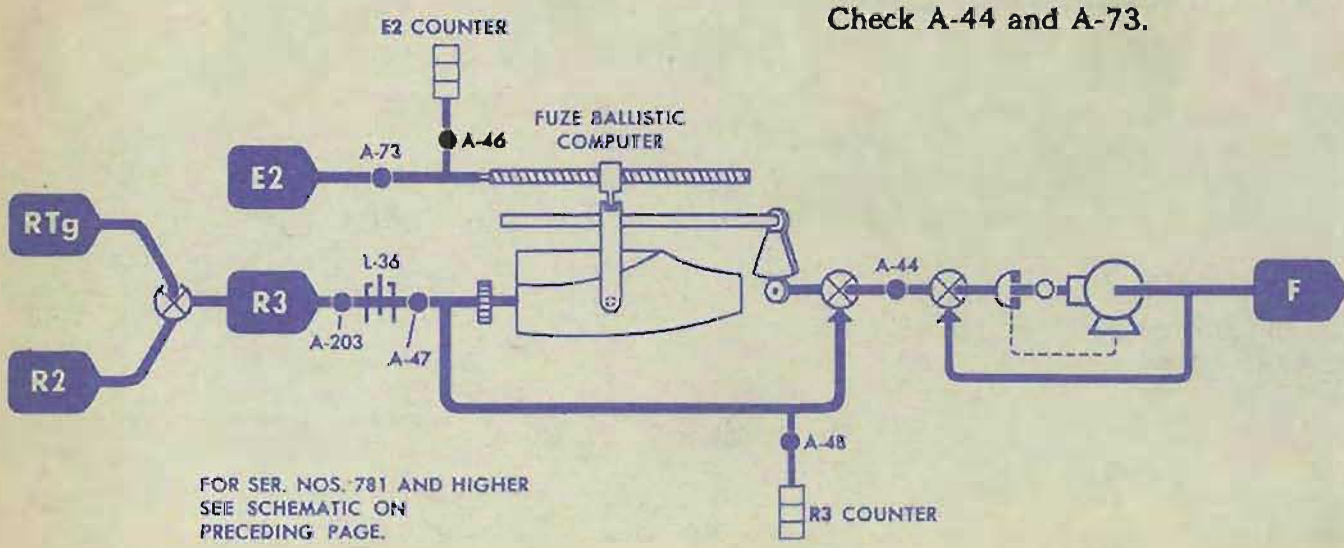
A-46 is under cover 4, in the fuze ballistic computer.

Check

Turn the power OFF.
Set *E2* and *R3* (*F* on Ser. Nos. 781 and higher) at the values listed on the legend plate.
Loosen A-209 on the fuze follow-up damper and push the damper to the end of the shaft.
Insert a 3/16-inch setting rod through the casting, the follower arm, and the cam.
If it is necessary to change the *E2* input, A-46 is upset and should be readjusted.

Adjustment

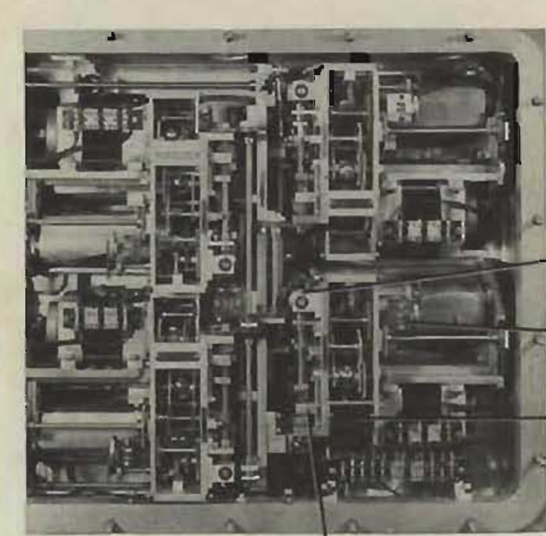
With the setting rod inserted, loosen A-46. Turn the *E2* counter until it reads the value specified on the legend plate.
Tighten A-46 and recheck.
Remove the setting rod.
Replace the damper on the follow-up shaft and tighten A-209.
Check that *E2* can be moved from 0° to 90°.
Check A-44 and A-73.



A-47 R3 COUNTER to L-36
SER. NOS. 780 and LOWER

Location

A-47 and L-36 are under cover 4, in the fuze ballistic computer.

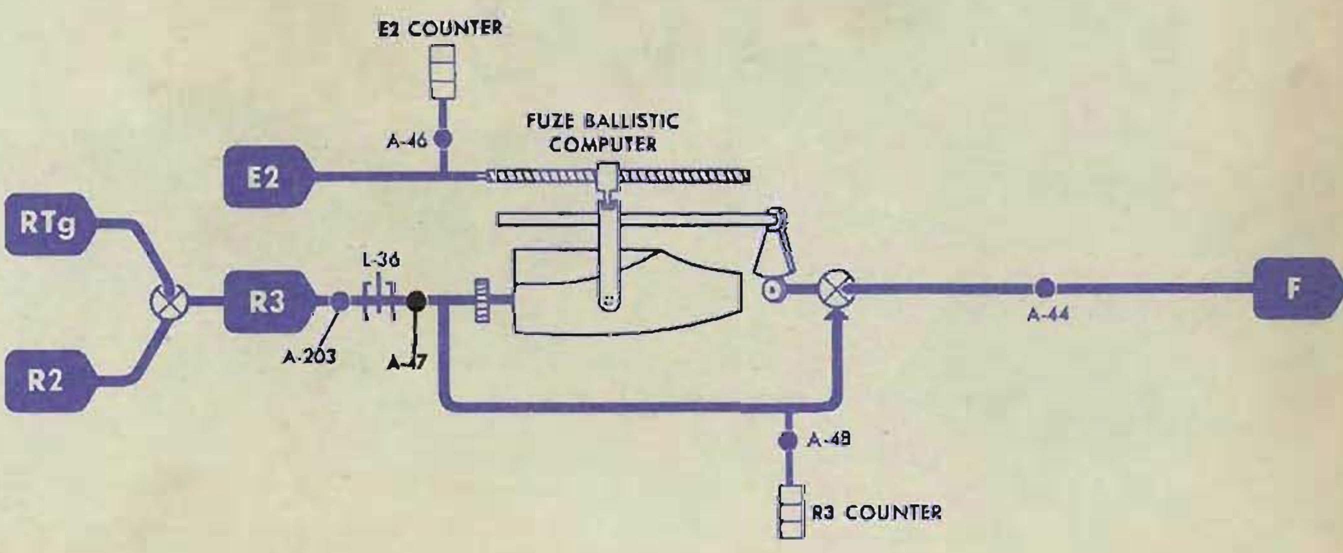


Check

Turn the power OFF.
Loosen A-203.
Turn the *R3* input to the fuze ballistic computer from limit to limit.
The *R3* counter should read −1250 yards at the low limit, and 19,750 yards at the high limit on Mods 3, 4, 6, 7, 10, and 13 below Ser. Nos. 781. On Mods 0, 1, 2, and 9, the limits are −250 and 19,750 yards.

Adjustment

If the *R3* counter does not read the proper values, loosen A-47. Hold the line against one limit and turn the *R3* counter gearing until the counter reads the proper value. Tighten A-47 and recheck.
Readjust A-203.
Check A-44.



A-47 F COUNTER to F BALLISTIC CAM
SER. NOS. 781 and HIGHER

Location

A-47 is under cover 4, in the fuze ballistic computer.

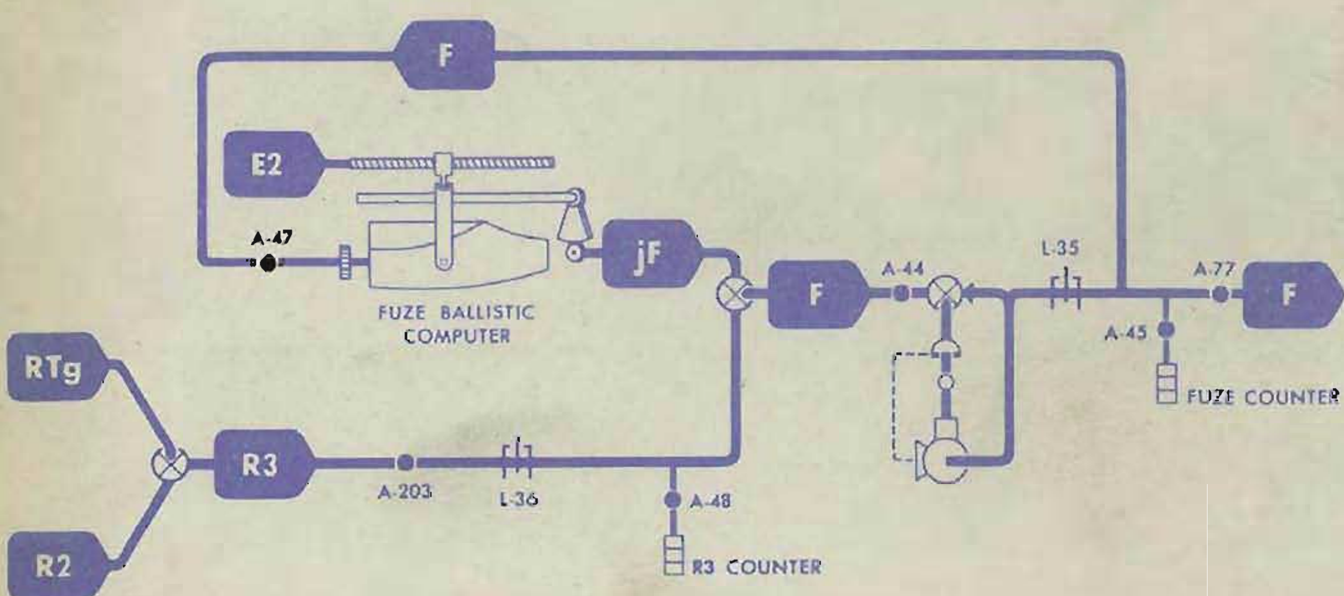
E^2 - 9005
F 3999

Check

Turn the power OFF.
Set *E2* and *F* at the values listed on the legend plate.
Loosen A-209 on the fuze follow-up damper, and push the damper to the end of the shaft.
Insert a 3/16-inch setting rod through the casting, the follower arm, and the cam.
If it is necessary to change the *F* input to insert the rod, A-47 is upset and should be readjusted.

Adjustment

With the setting rod inserted, loosen A-47. Turn the *F* line until the counter reads the value specified on the legend plate.
Tighten A-47 and recheck.
Remove the setting rod.
Replace the damper on the follow-up shaft and tighten A-209.
Check A-44.



A-48 R3 COUNTER to L-36
SER. NOS. 781 and HIGHER

Location

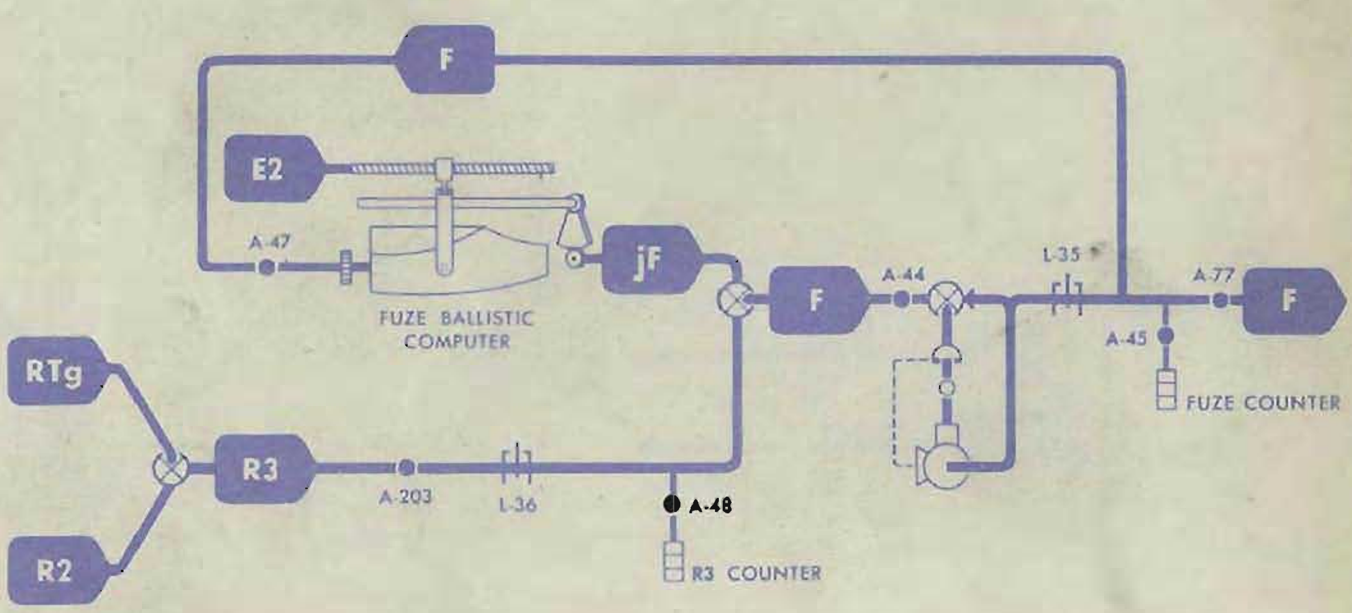
A-48 and L-36 are under cover 4, in the fuze ballistic computer.

Check

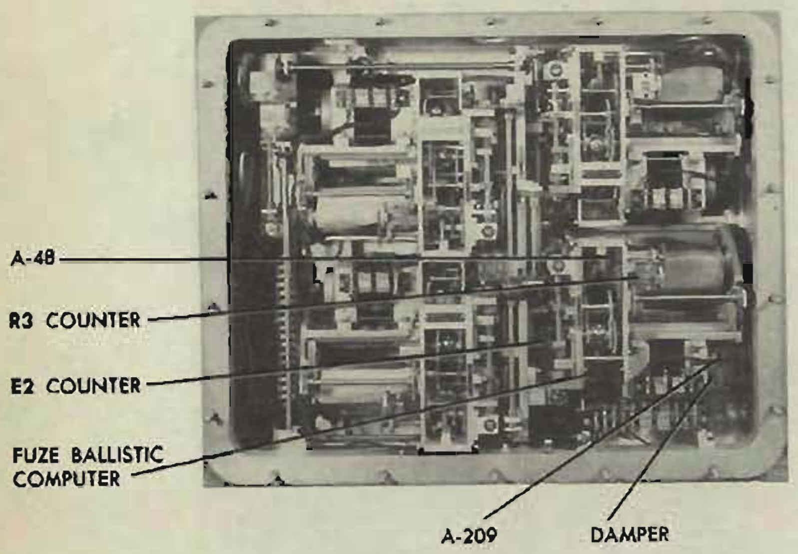
Turn the power OFF.
Loosen A-203.
Turn the *R3* input to the lower limit.
The *R3* counter should read −13,150 yards (86850) in Mod 13, or −13,350 yards (86650) in Mods 8 and 12.
Check at the higher limit. In Mod 13 the higher limit is +31,650 yards. In Mods 8 and 12, the higher limit is +33,850 yards.

Adjustment

If the *R3* counter does not read the proper values, loosen A-48.
Hold the line against the stop and turn the *R3* counter gearing until the counter reads the correct value.
Tighten A-48 and recheck.
Readjust A-203.
Check A-44.



A-48 R3 COUNTER to F BALLISTIC COMPUTER
SER. NOS. 780 and LOWER



Location

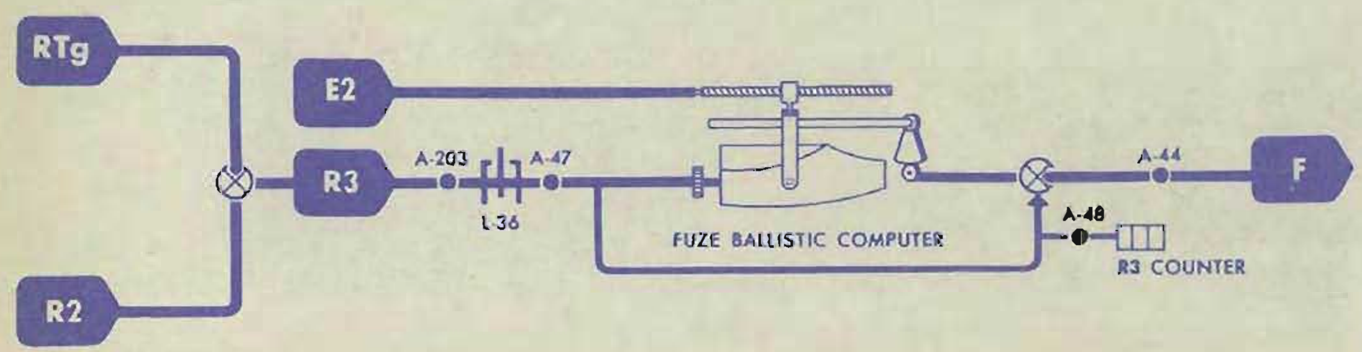
A-48 is under cover 4, in the fuze ballistic computer.

Check

Turn the power OFF.
Set *E2* and *R3* at the values listed on the legend plate.
Loosen A-209 on the fuze follow-up damper, and push the damper to the end of the shaft.
Insert a 3/16-inch setting rod through the casting, the follower arm, and the cam.
If it is necessary to change the *R3* input to insert the rod, A-48 is upset and should be readjusted.

Adjustment

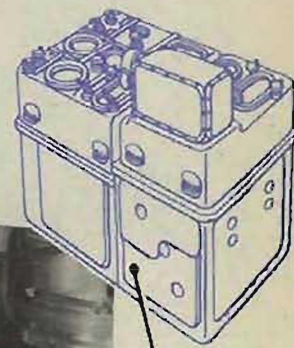
With the setting rod inserted, loosen A-48. Turn the *R3* counter gearing until the counter reads the value specified on the legend plate. Tighten A-48 and recheck.
Remove the setting rod.
Replace the damper on the follow-up shaft and tighten A-209.
Check A-47, A-44, and A-203.

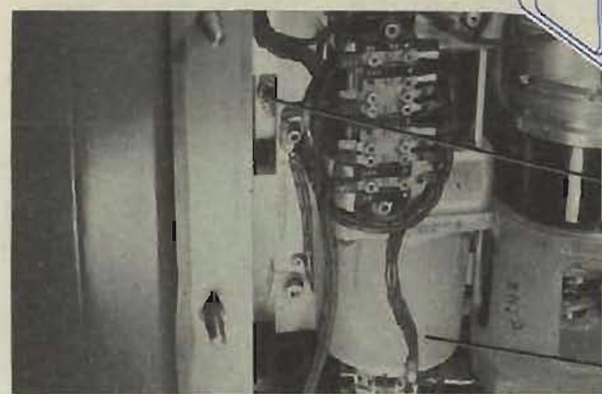


A-49 Ph COMPUTER to PARALLAX COMPONENT SOLVER

Location

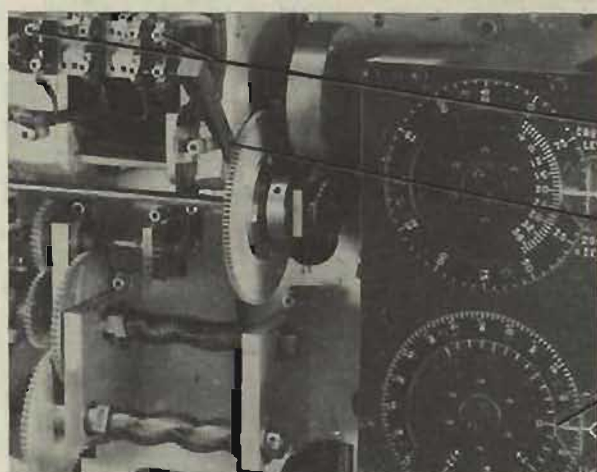
A-49 is under cover 6, at the left of the *Eb* receiver servo motor terminal block.





Check

Remove power leads 1B and 1BB on the *Dd* follow-up.
Turn the power ON.
Set *Dd* at 0° and wedge the gearing.
Turn the control switch to LOCAL.
Set *B'gr* at 0°, using the generated bearing crank.
Set *R2* at a high value.
Set *L* at 2000'.
Turn *E2* from 0° to 90°.
There should be no movement of the *Ph* dials.

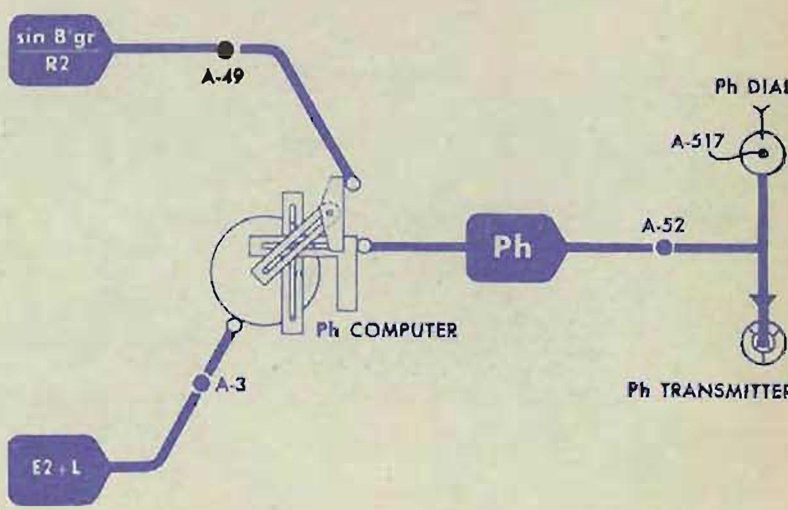


Adjustment

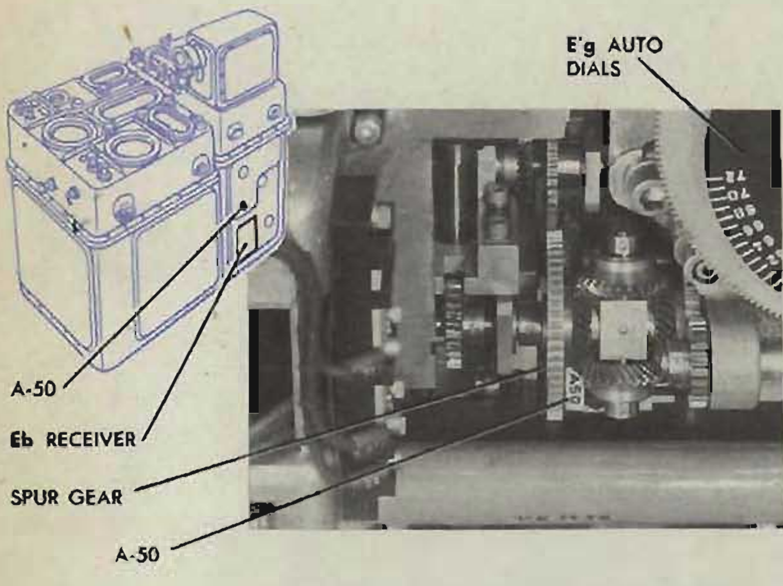
If there is movement of the *Ph* dials, make A-49 slip-tight.

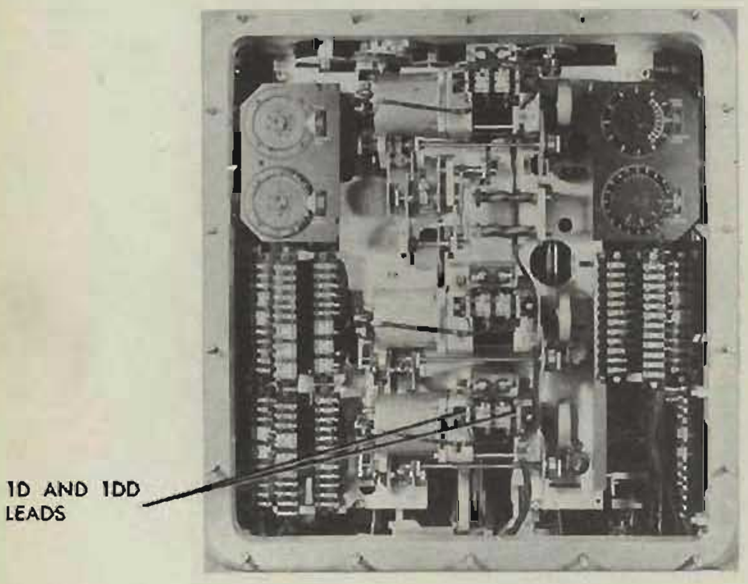
CAUTION: When A-49 is loosened, the input rack of the *Ph* computer may drop, causing damage to the unit. Make this clamp slip-tight, *while holding the input rack.*

Set *E2* at 0° and read the *Ph* dial.
Run *E2* to 75°.
Turn the small spur gear which is 1½ inches to the left of A-49, until the *Ph* dial reads the original value.
Run *E2* to 0° and take a new reading of *Ph*.
Again run *E2* to 75° and correct as before.
Continue the adjustment until there is no motion of *Ph* for full travel of *E2*.
Tighten A-49.
Remove the wedge and replace the power leads on the *Dd* follow-up.
Check A-52 and A-3.



A-50 E'g DIALS to Eb RECEIVER





Location

A-50 is under cover 6, above the *Eb* receiver.

Check

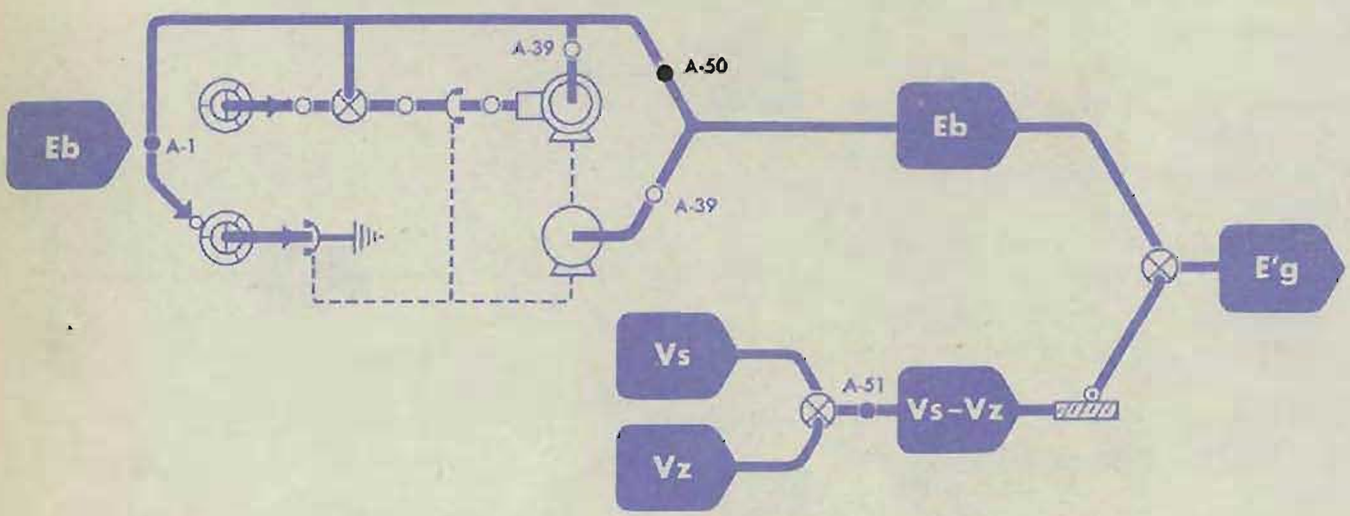
Remove power leads 1D and 1DD from the *Vz* follow-up.
Set *Vz* at 0 and wedge the line.
Turn the power ON.
Set *Vs* at 2000'.
Put the sync *E* handcrank at CENTER.
Transmit *Eb* from the director.
The value read on the *E'g* dials should agree with the *Eb* value transmitted from the director.
Check A-51 before readjusting A-50.

Adjustment

If the *E'g* dials do not read the correct value, slip-tighten A-50. Turn the spur gear next to the clamp until the *E'g* dials read the proper value.

Tighten A-50 and recheck.

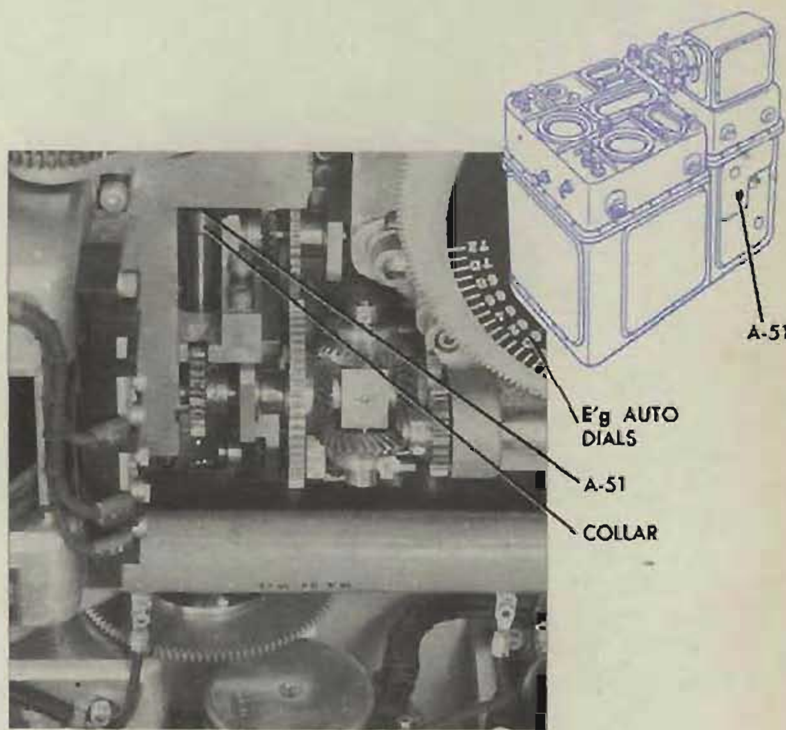
Remove the wedge.



A-51 E'g DIALS to Vs – Vz LINE

Location

A-51 is under cover 6.



Check

Turn the power OFF.
Set *L* at 2000'.
Set *Vs* at 2000'.
Set *E* at 0° with the sync *E* handcrank at CENTER and match the sync *E* dials at the fixed index with the handcrank OUT.
Set *Vz* at 0 by turning the output gearing on the *Vz* servo motor.
The *E'g* dials should read 2000'.

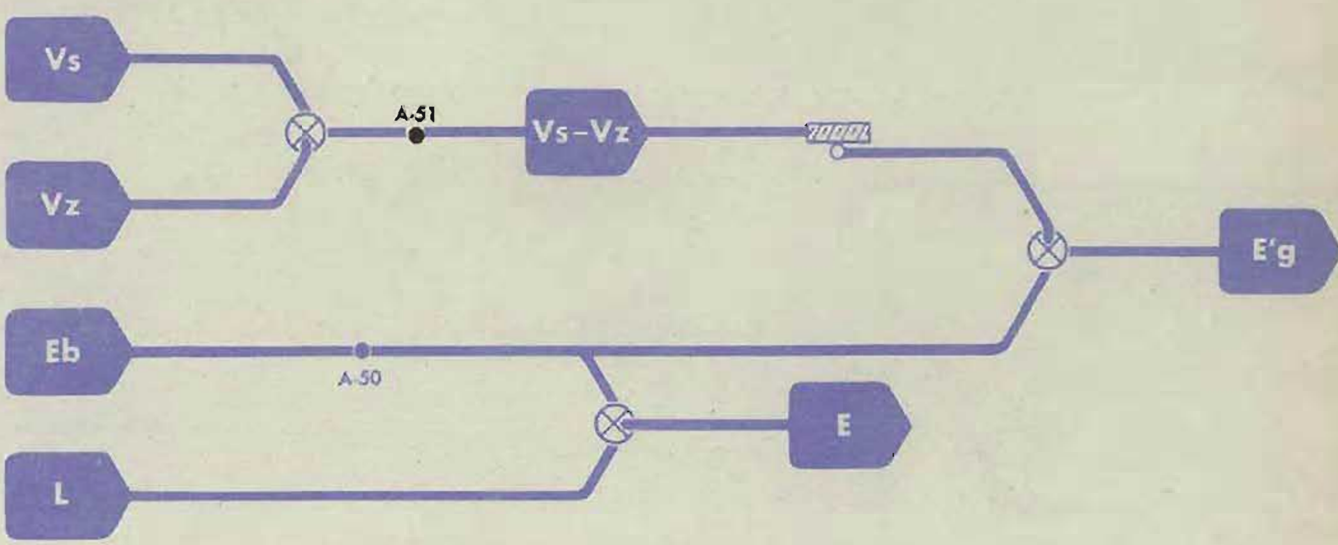
Adjustment

If the *E'g* dials do not read 2000', loosen A-51. Set the *Vz* dials at 0, and wedge the *Vz* line. Turn the collar on the shaft below the clamp until the *E'g* dials read 2000'.

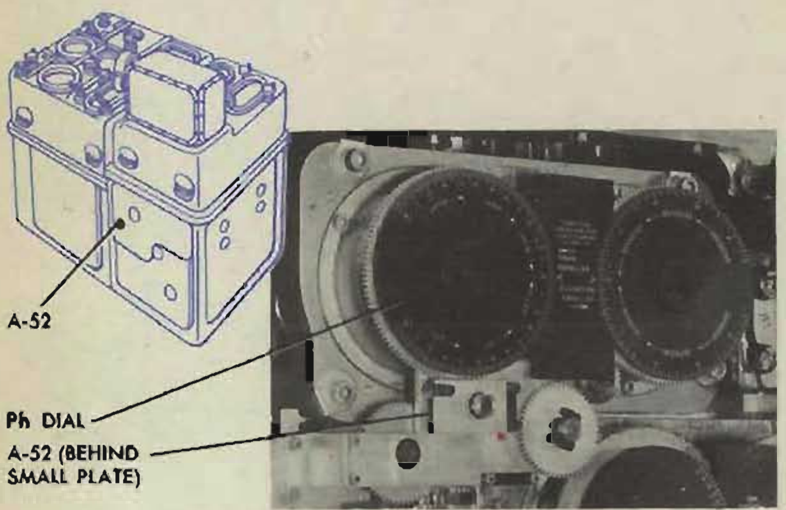
Tighten A-51 and recheck.

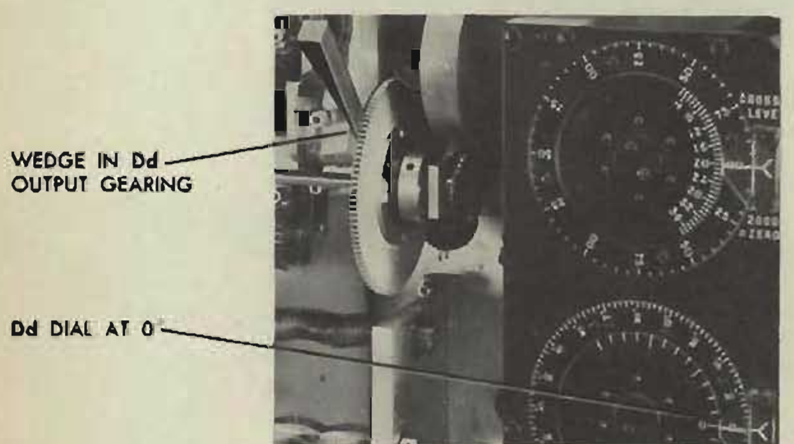
Readjust A-50.

Remove the wedges.



A-52 Ph DIAL to Ph COMPUTER





Location

A-52 is under cover 6, behind the small plate below the *Ph* dial.

Check

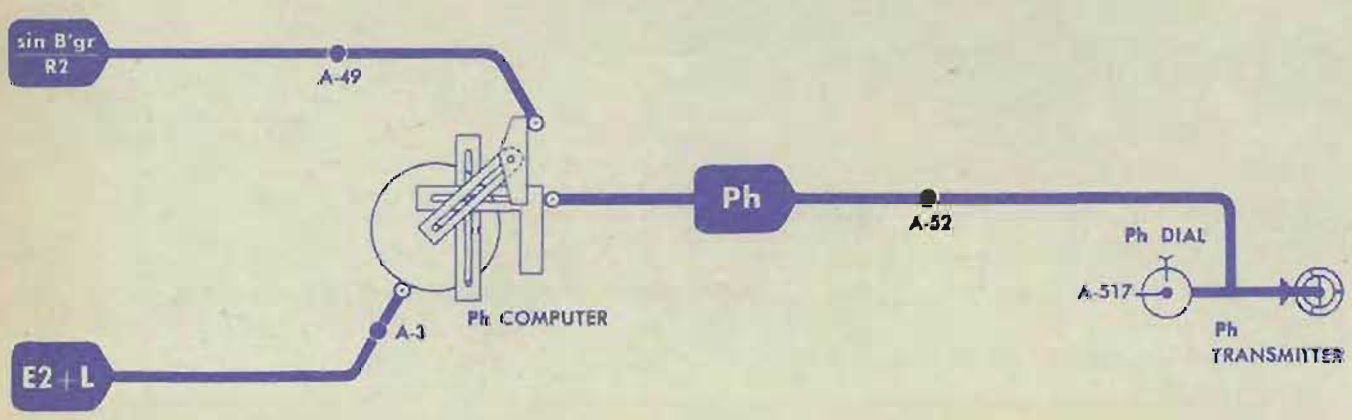
Turn the power OFF.
Set *Dd* at 0° and wedge the line.
Set *B'gr* at 0°.
The *Ph* dial should read 0°.

Adjustment

If the *Ph* dial does not read 0°, check A-517. Make A-52 slip-tight. Slipping through A-52, turn the large gear on the rotor of the *Ph* transmitter until the dial is at its proper reading.

Tighten A-52 and recheck.

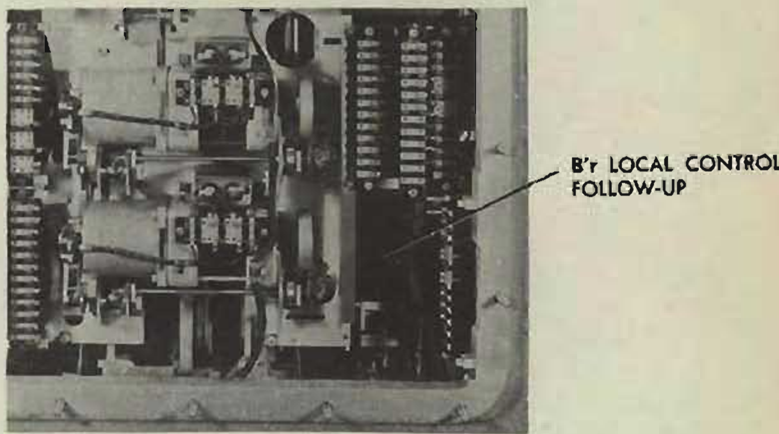
Remove the wedge.



A-53 ASSEMBLY CLAMP

Location

A-53 is under cover 7, on the servo output shaft of the *B'r* local control follow-up.

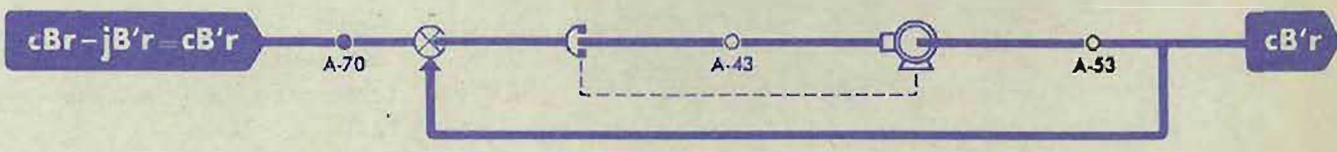


Check

If A-53 is loose, the energized *B'r* local control servo may run without driving the *cB'r* line.

Adjustment

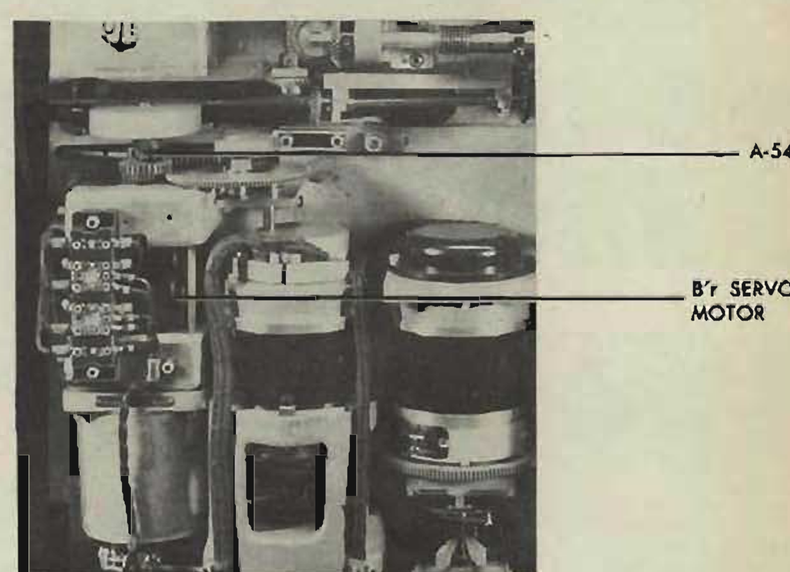
Tighten A-53.



A-54 ASSEMBLY CLAMP

Location

A-54 is under cover 8, on the servo output shaft of the *B'r* receiver.



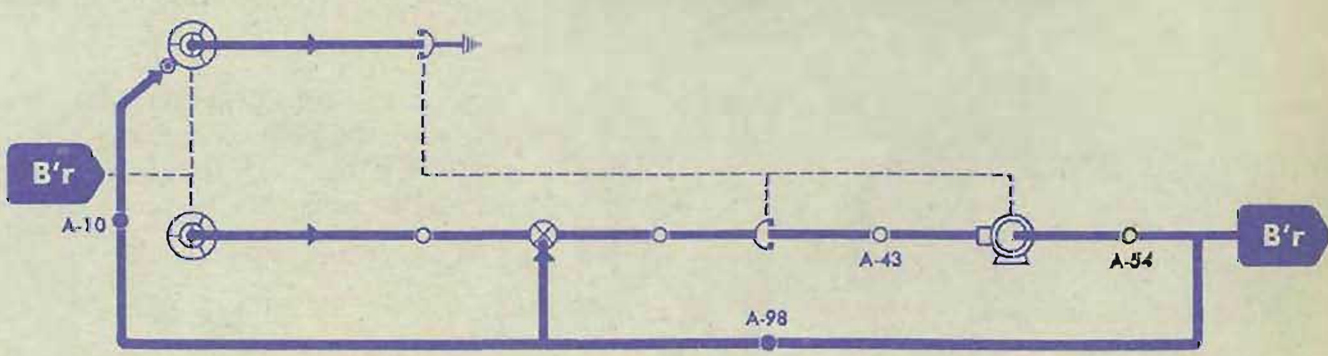
Check

If A-54 is loose, the *B'r* receiver servo may run without driving the *B'r* line.

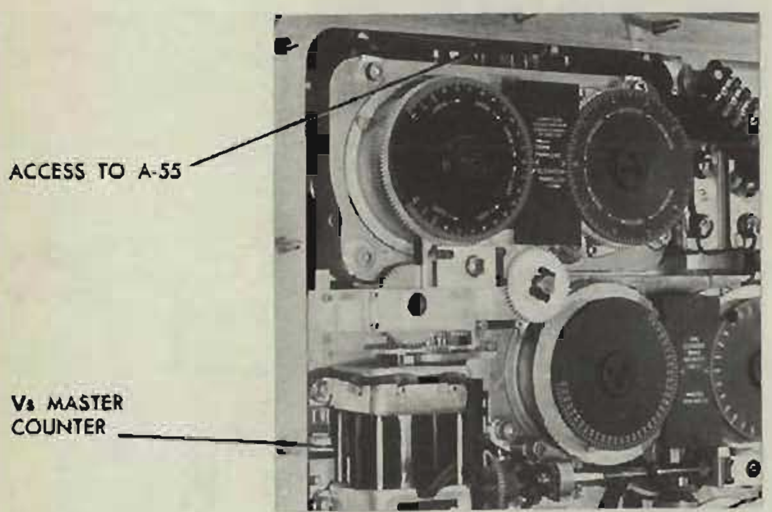
Adjustment

Make sure that the servo output cluster gear is in mesh. Then tighten A-54. Make sure A-209 on the magnetic damper above A-54 is also tight.

Check A-98.



A-55 Vs INDICATING to Vs MASTER COUNTER

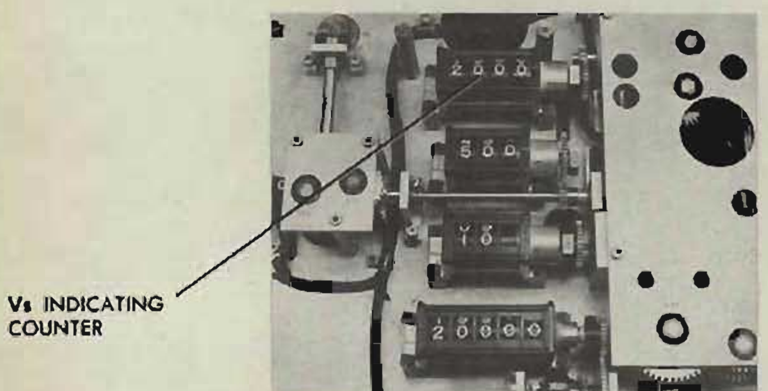


Location

A-55 is under cover 6, directly in front of the *Vs* intermittent drive. It is reached by inserting a long screw driver through the access over the *Ph* transmitter.

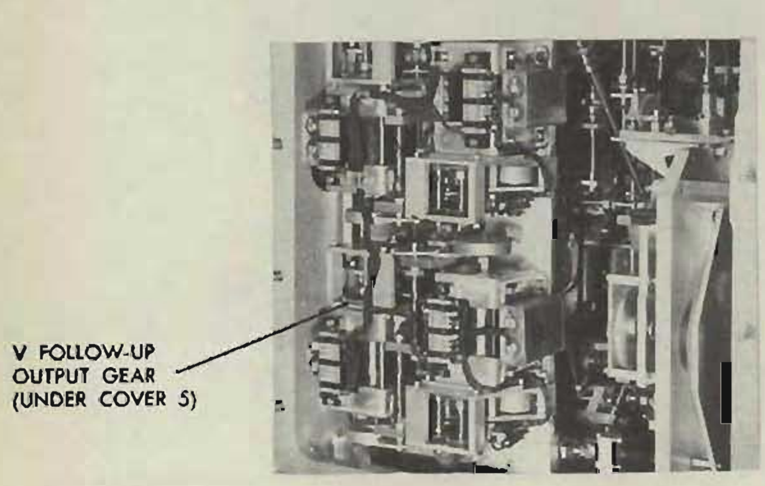
The *Vs* indicating counter is under cover 2, beside the *Vs* handcrank.

The *Vs* master counter is under cover 6, behind the *Eb* servo motor.



Check

Both *Vs* counters should agree.

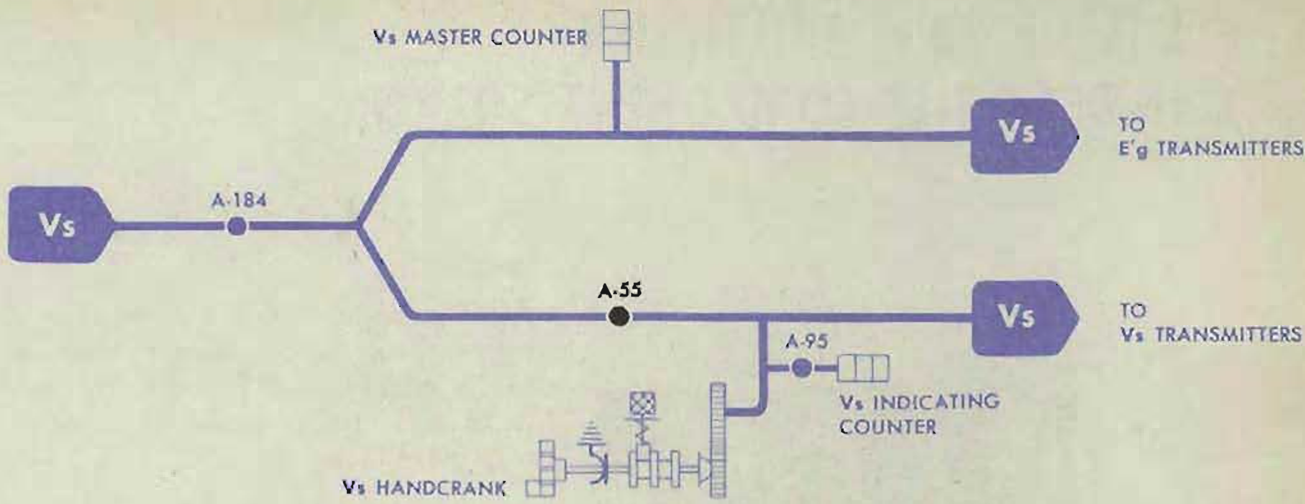


Adjustment

If the *Vs* counters do not agree, make A-55 slip-tight.

Turn the power ON. Hold the *Vs* setting with the *Vs* handcrank in the IN position. Turn the *V* follow-up output gearing to bring the *Vs* master counter to the same reading.

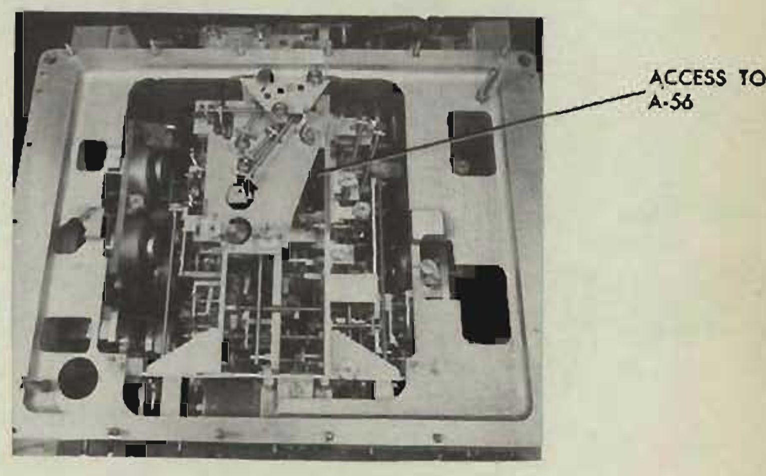
Tighten A-55 and recheck. Check A-184, A-95.



A-56 ASSEMBLY CLAMP

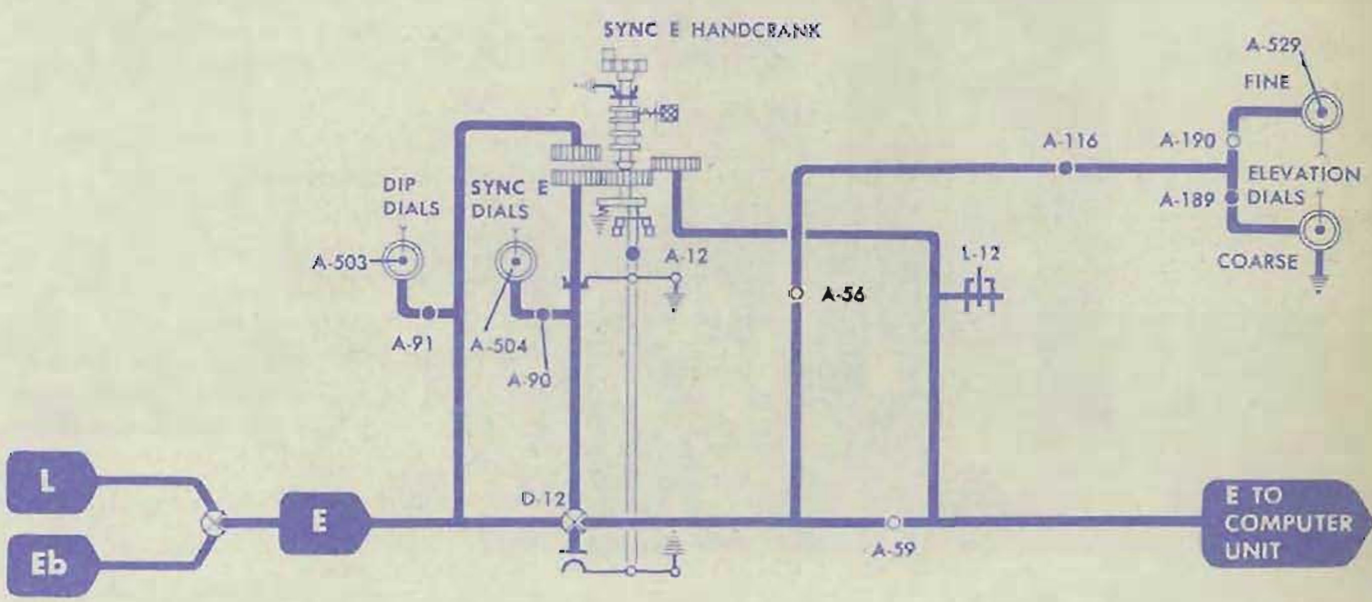
Location

A-56 is on the *E* line at D-12 in the corrector unit. It can be reached only when the indicator unit is removed from the corrector unit. On computers with Ser. Nos. 290 and lower, A-56 is the common type of adjustment clamp. On computers with Ser. Nos. 291 and higher, it is a square clamp which closes firmly against a flat on the shaft

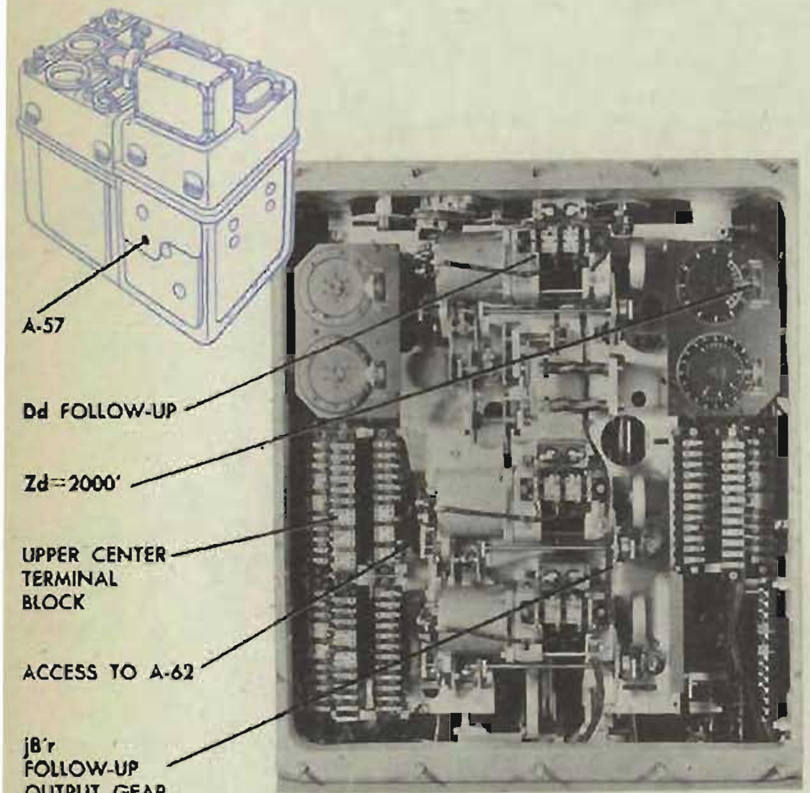


Check

A-56 is checked and readjusted in the same way as A-59.



A-57 L (L sin 2B'r) MULTIPLIER to DECK TILT COMPONENT SOLVER

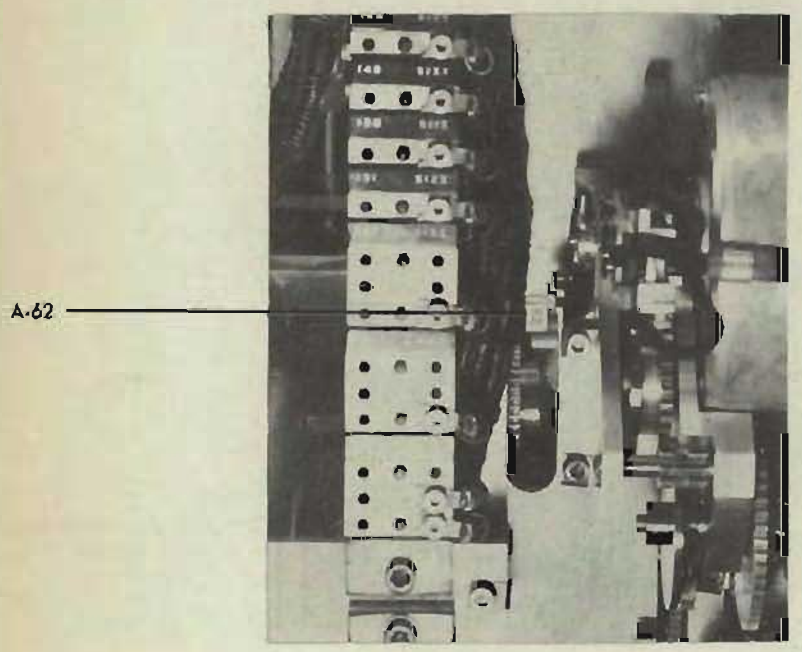


Location

A-57 is under cover 7. To reach it, remove the upper center terminal Llock near the *jB'r* follow-up contacts. A-57 is 20 inches in from the terminal block.

Check

Set *Dd* at 0°.
Remove leads 1B and 1BB from the *Dd* follow-up and wedge the output gearing.
Turn the power ON.
Turn the control switch to LOCAL.
Set *Zd* at 2000'.
Set *B'gr* at 0°, using the generated bearing crank.
Turn *L* from 800' to 3200'.
There should be no motion of the *L*(*L* sin *2B'r*) output rack for the full travel of *L*.
Observe A-62 for motion of the output rack. If A-62 moves, A-57 is in error and should be readjusted.

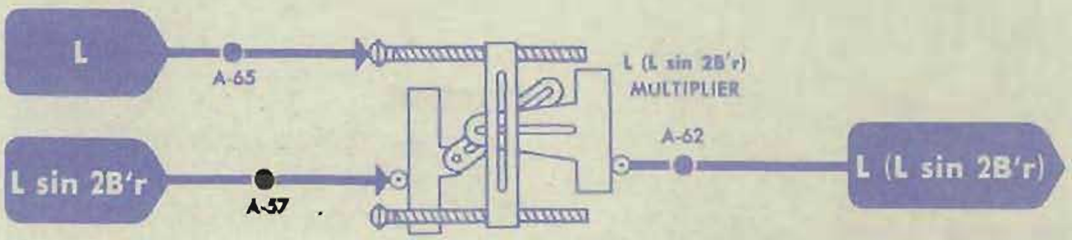


Adjustment

With *L* at 2000', mark the *jB'r* follow-up output gear for use as an indicator.
Turn *L* to 3200'. Make A-57 slip-tight.
WARNING: If A-57 is loosened too much, the input slide of the multiplier will fall.
With a gear pusher, turn the spur gear next to A-57 until the *jB'r* follow-up gear is at the original mark.
Turn *L* to 800' and continue the adjustment until there is no motion of the follow-up gear for full travel of *L*.
Tighten A-57 and recheck.
Remove the wedge and replace the leads on the *Dd* follow-up.

REMINDER

Replace the terminal block at the left of the *jB'r* follow-up.
Check A-62.

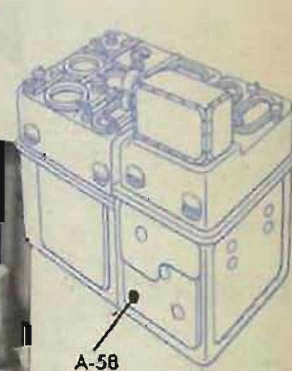


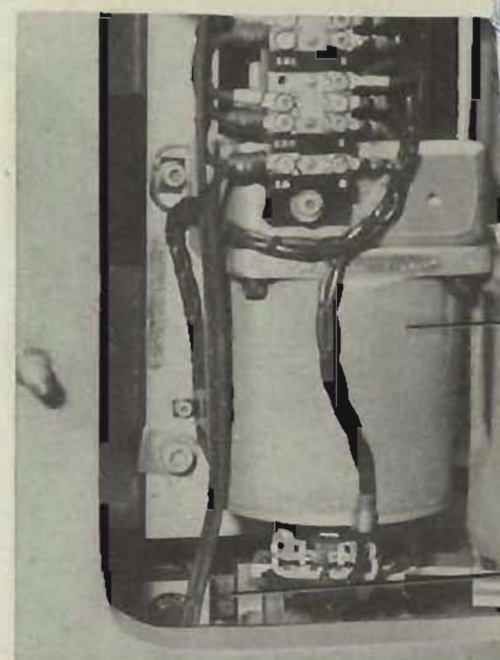
A-58 L DIALS to L-16

Location

A-58 is under cover 6, below the lower *Eb* follow-up.

L-16 is under cover 7, in front of the *L* stub shaft to the stable element. The upper limit is at the rear.



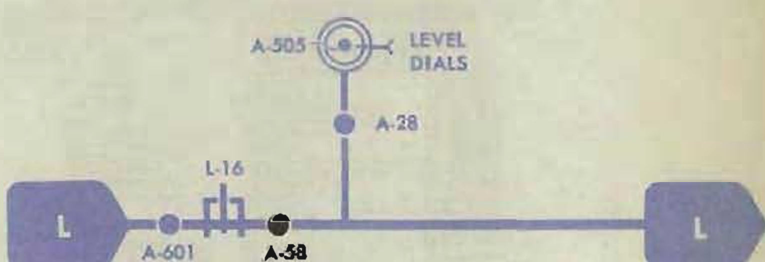


Check

Put the sync *E* handcrank at CENTER.
Loosen A-601.
Turn the *L* line to check the readings of the computer *L* dials at the limits of L-16.
The *L* dials should read 480′ at the lower limit and 3520′ at the upper limit.

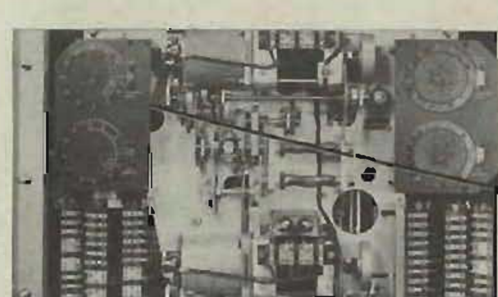
CAUTION

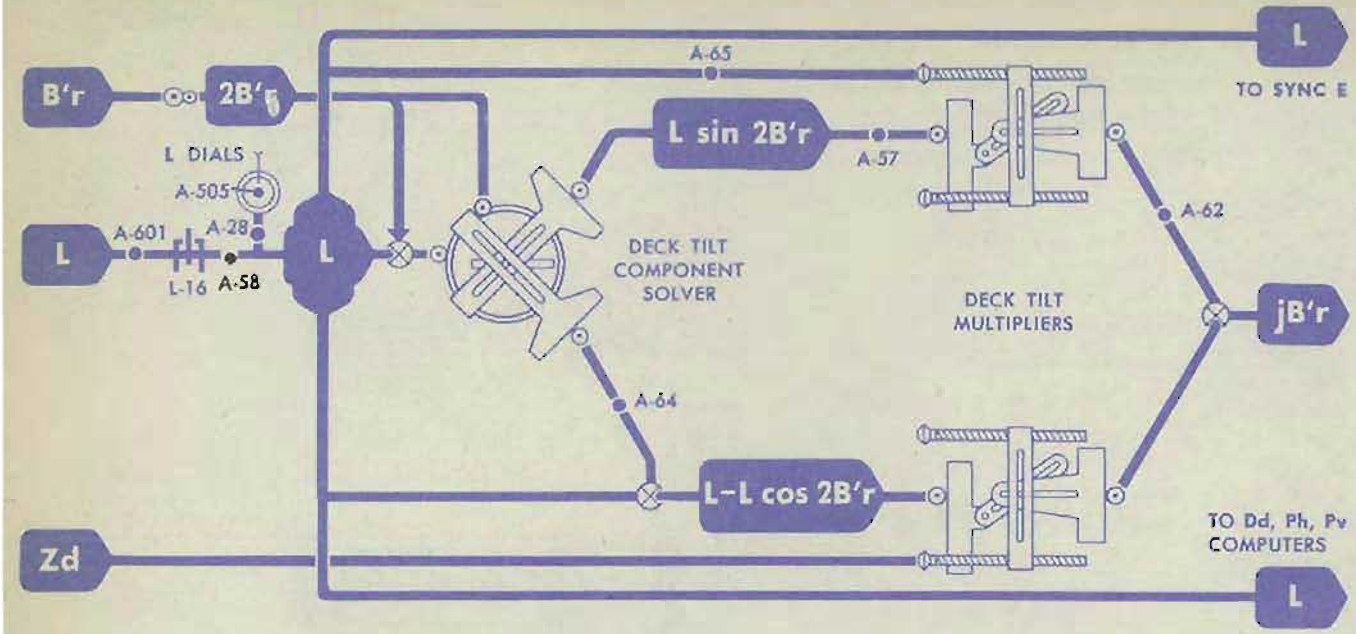
In case either limit cannot be reached, check A-28, and readjust if necessary.
Check A-64, A-65, A-57, A-34, A-227 and A-3.
Determine which adjustment is in error. Loosen it and readjust later.



Adjustment

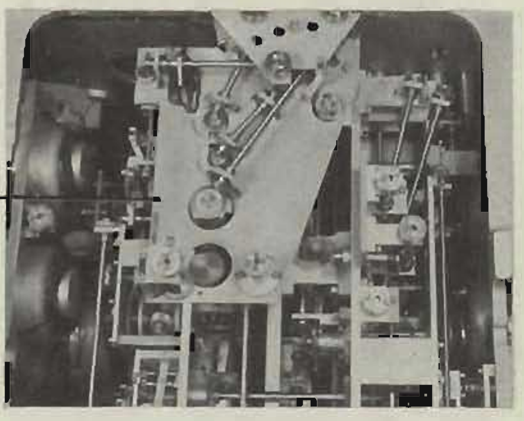
If the readings of the dials are incorrect, make A-58 slip-tight.
Hold the *L* shaft line against either limit and set the *L* dials at their proper value by turning the square mounting plate behind the *L* dials.
Tighten A-58 and recheck the readjustment at the other limit.
Split any error.
Readjust A-601.





A-59 ASSEMBLY CLAMP

REMOVE THIS PLATE TO REACH A-59



Location

A-59 is on D-12 in the *E* line in the corrector unit. It can be reached only after removal of the indicator unit and the top plate of the corrector unit. On computers with Ser. Nos. 290 and lower, A-59 is the common type of adjustment clamp. On computers with Ser. Nos. 291 and higher, it is a square clamp which closes firmly against a flat on the shaft.

Check

Put the sync *E* handcrank in the CENTER position.

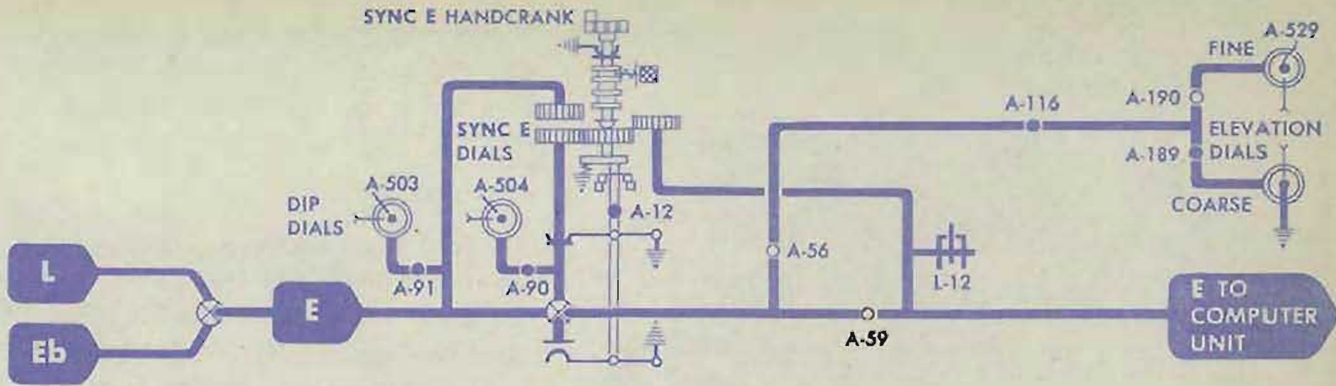
Check that the limits of *E* are correct:

$-5°$ to $+85°$ on Ser. Nos. 389 and lower.

$-25°$ to $+85°$ on Ser. Nos. 390 and higher.

If the limits of *E* are incorrect, check A-116 for looseness. If A-116 is tight and shows no signs of slippage, either A-56 or A-59, or both, may have slipped.

NOTE: On computers with Ser. Nos. 291 and higher, A-56 and A-59 cannot slip when properly assembled.



Adjustment

Tighten A-59 and A-56.

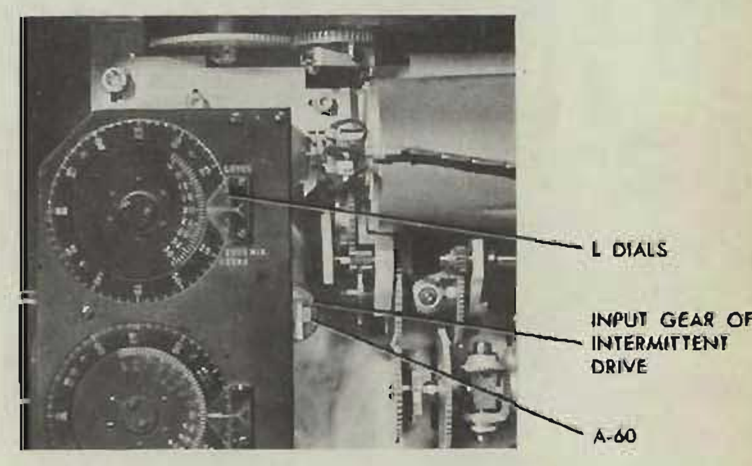
Reinstall the top plate and the indicator unit.

Readjust by *Factory Adjustment Procedure*, page 815.

A-60 Eb+Vs INTERMITTENT DRIVE to Eb+Vs LINE

Location

A-60 is under cover 7, on the input gear of the *Eb* + *Vs* intermittent drive. It can be seen through the access hole next to the *L* dial mask.



Check

Set *E* at 80° with the sync *E* handcrank at CENTER. Match the sync *E* dials at the index, with the handcrank OUT.

Set *L* at 2000′.

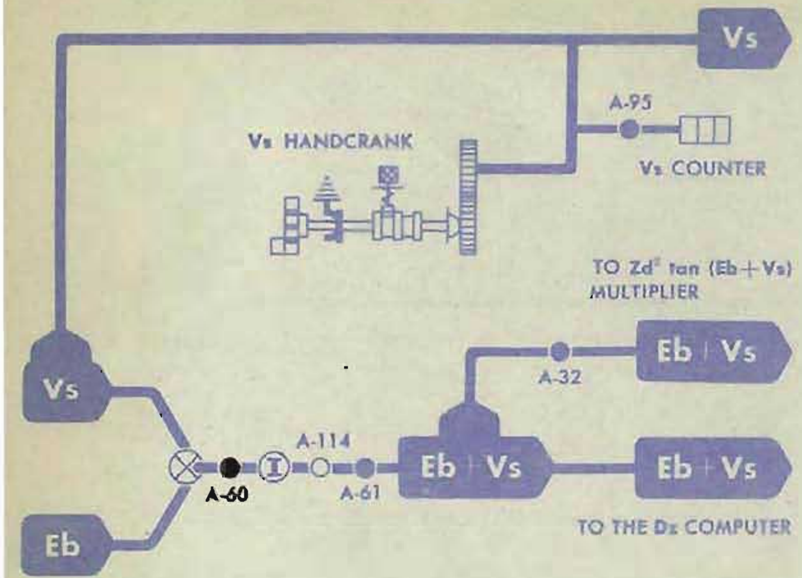
Increase *Vs* while observing the output gear of the intermittent drive. It should stop turning when the *Vs* counter reads 2360′.

NOTE: Check that *E* and sync *E* remain as set.

Adjustment

If the intermittent drive output gear does not stop turning when *Vs* reads 2360′, make A-60 slip-tight.

Turn *Vs* in an increasing direction to the point where the output gear stops turning. This is the upper cut-out point of the intermittent drive.



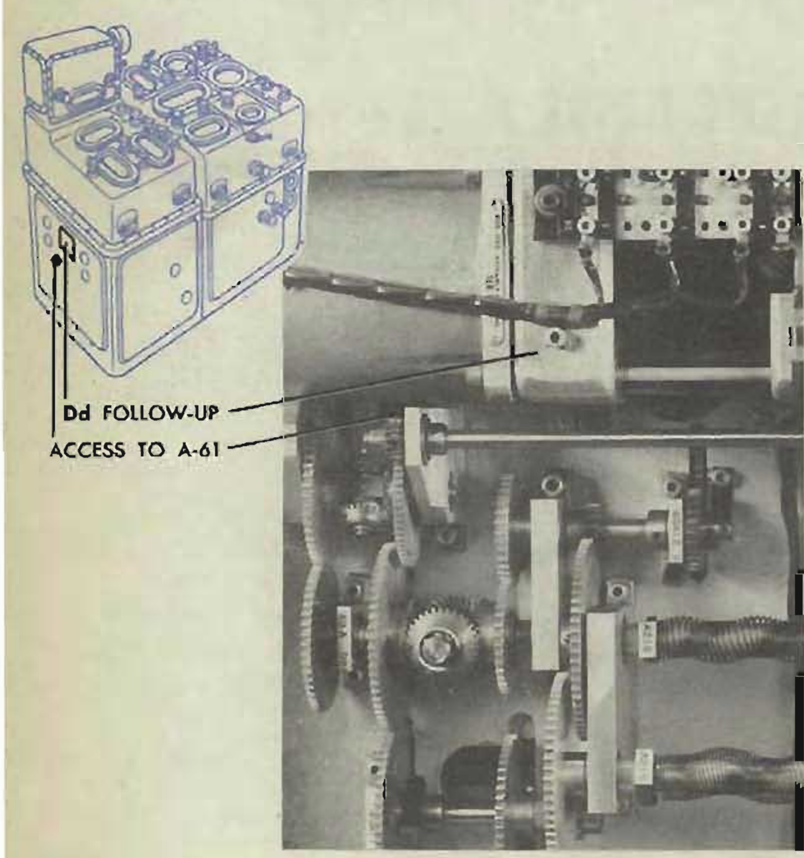
Use a gear pusher to hold the spider disk on the intermittent drive. Set the *Vs* counter to 2360′ with the *Vs* handcrank.

Tighten A-60.

Check at the lower cut-out point. Set *E* at 0°. Match the sync *E* dials at the fixed index. Decrease *Vs*.
The intermittent drive should cut out when the *Vs* counter reads 1640′.

Check A-61 and A-32.

A-61 Dz COMPUTER to Eb + Vs LINE



Location

A-61 is under cover 7. It may be reached through the hole below the compensator assembly of the *Dd* follow-up.

Check

Turn the power ON.
Set *L* at 2000′.
Set *E* at 60° with the sync *E* handcrank at CENTER.
Match the sync *E* dials at the fixed index, with the handcrank OUT.
Set *Ds* at 500 mils.
Set *Vs* at 2000′.
Set *Zd* at 3200′.
The *Dd* dials should read +30°34′.

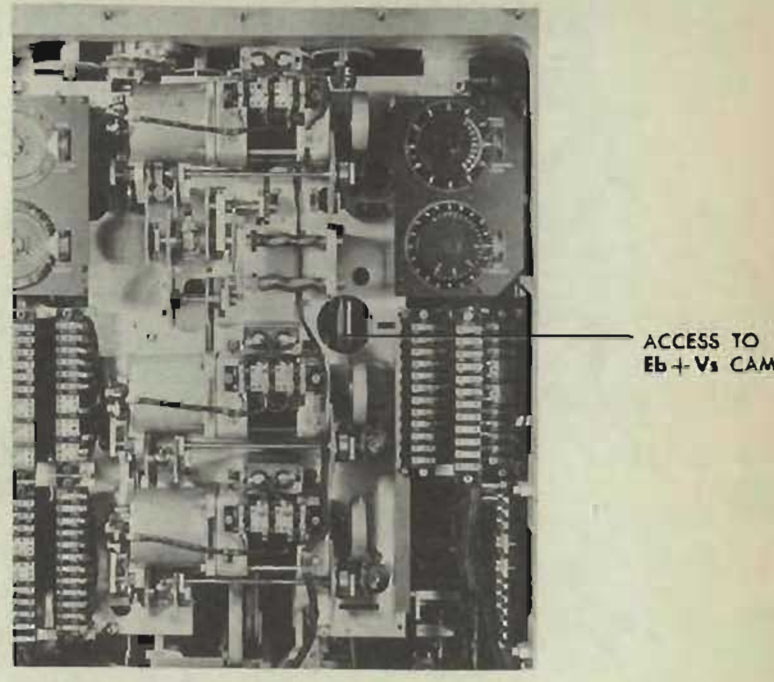
Adjustment

If the *Dd* dials do not read +30°34′, check A-35 and A-36 and readjust them if necessary.

Make A-61 slip-tight.

Turn the *Eb* + *Vs* cam until the *Da* dials read the proper value.

The *Eb* + *Vs* cam is next to the mounting plate of the *Dz* computer. It can be reached by a gear pusher inserted through the hole above the *jB'r* follow-up.



IMPORTANT

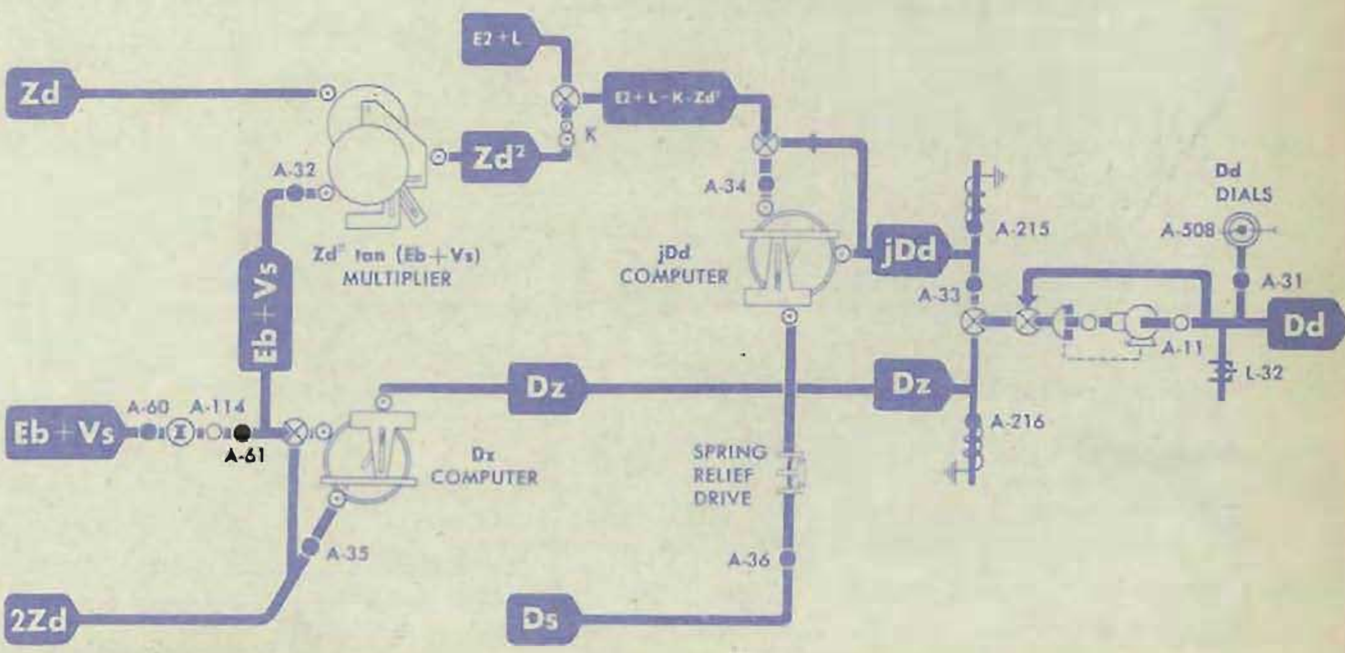
If any interference is felt while adjusting A-61, loosen A-32.

Tighten A-61.

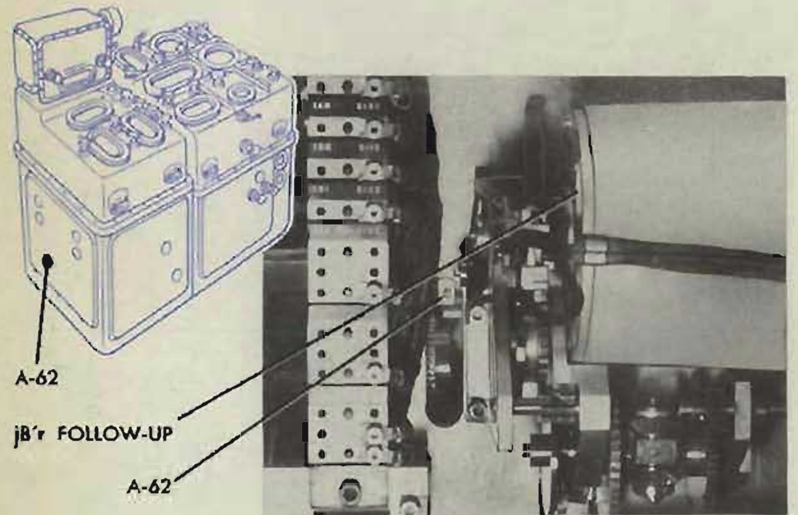
Recheck

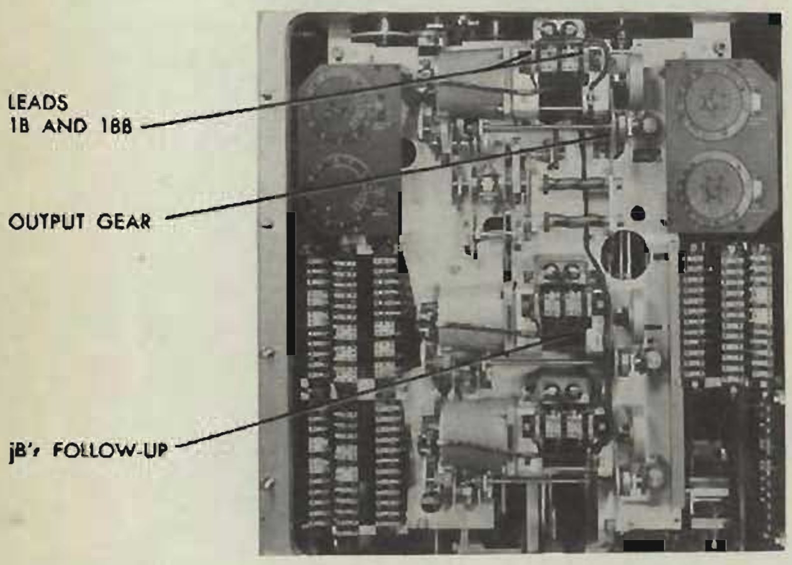
Decrease *Zd* to 800'.
The *Dd* dials should read −30°34'.
Split the error.

Check A-114 and A-32.



A-62 SYNCHRONIZING THE jB'r FOLLOW-UP





Location

A-62 is under cover 7. It is reached through a hole next to the contacts of the *jB'r* follow-up.

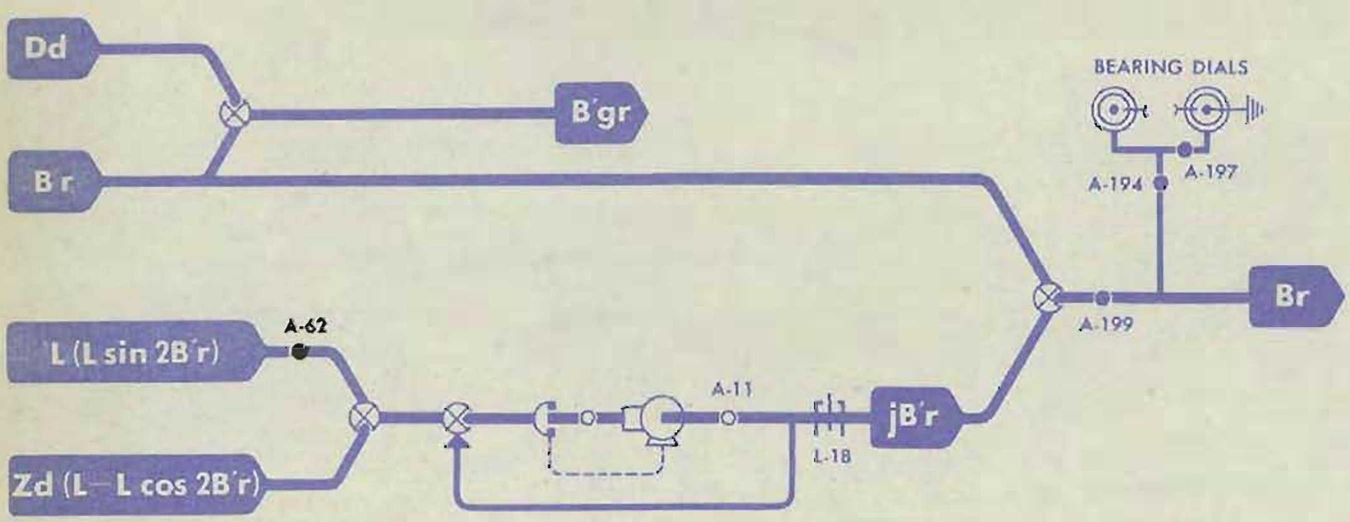
Check

At the switchboard, turn the *B'r* receiver switch OFF.
Set *Dd* at 0°.
Remove leads 1B and 1BB from the *Dd* follow-up, and wedge the output gearing.
Turn the power ON.
Set *L* and *Zd* at 2000'.
Set *B'gr* at 0°, and wedge the line.
The *Br* dials should read 0°.

Adjustment

If the *Br* dials do not read 0°, check A-199. Make A-62 slip-tight. Use a gear pusher to turn the spur gear at the rear of A-62 until the *jB'r* follow-up drives the *Br* dials to 0°.
Tighten A-62, and recheck.

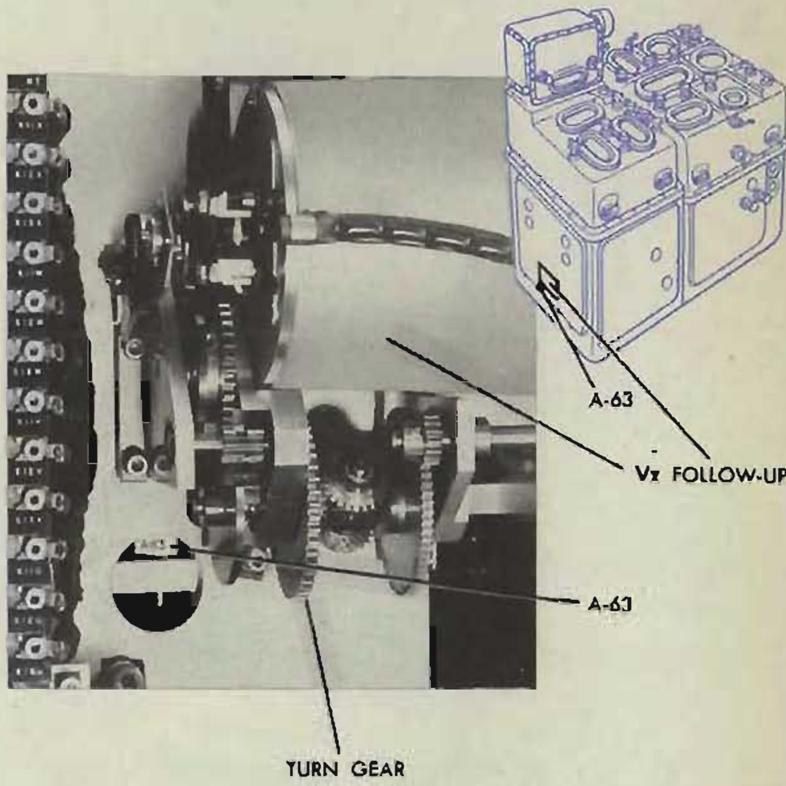
Remove all wedges and replace the *Dd* power leads.



A-63 SYNCHRONIZING THE Vz FOLLOW-UP

Location

A-63 is under cover 7. It is reached through the small hole below the *Vz* follow-up.



Check

Turn the power ON.

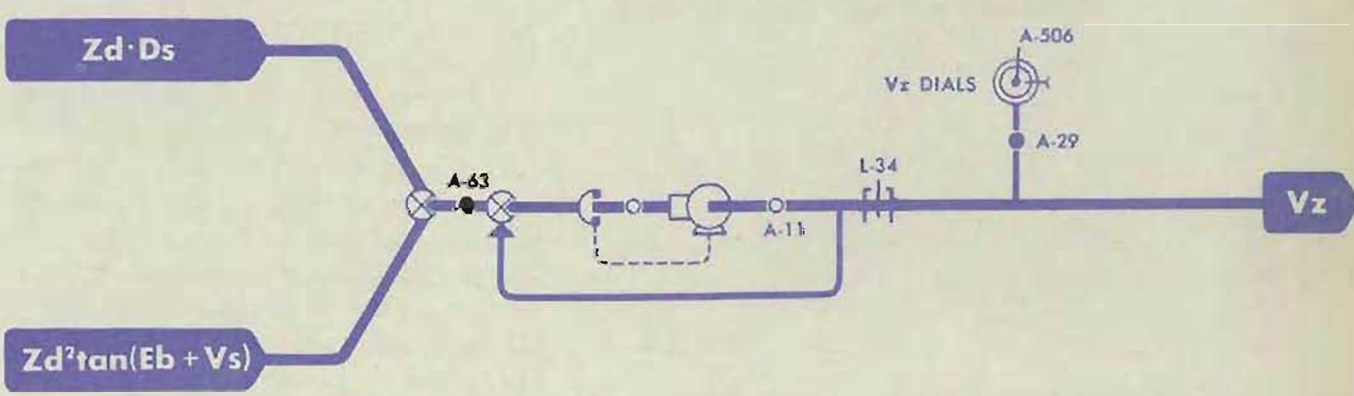
Set *L* at 2000′.
Set *E* at 0° with the sync *E* handcrank at CENTER and match the sync *E* dials at the index with the handcrank OUT.
Set *Zd* at 2000′.
Set *Ds* at 500 mils.
Set *Vs* at 2000′.
The *Vz* dials should read 0′.

Adjustment

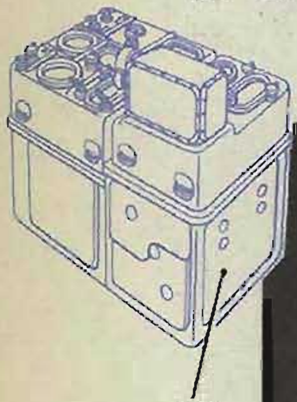
If the *Vz* dials do not read 0′, make A-63 slip-tight.

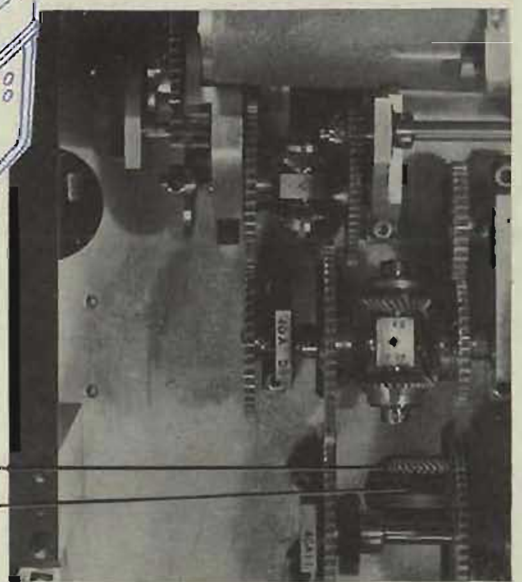
Turn the left side gear of the differential, below the *Vz* compensator assembly, until the *Vz* dials read 0′.

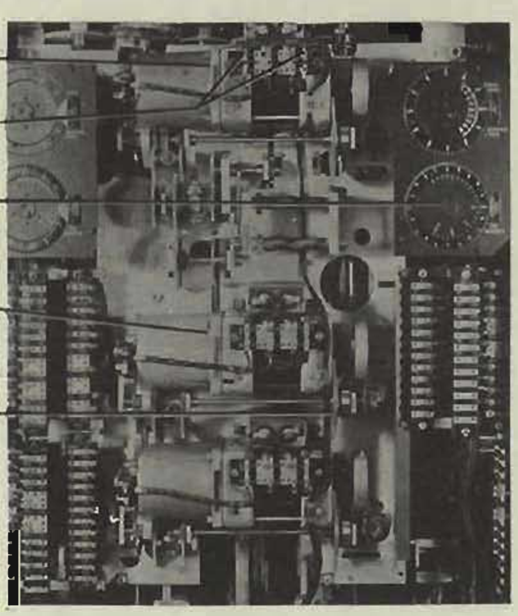
Tighten A-63 and recheck.



A-64 Zd (L − L cos 2B'r) MULTIPLIER to DECK TILT COMPONENT SOLVER







Location

A-64 is under cover 7. It is visible through the hole above the *jB'r* follow-up motor.

Check

Set *Dd* at 0°.
Disconnect leads 1B and 1BB from the *Dd* follow-up. Wedge the output gearing.
Turn the power ON.
Turn the control switch to LOCAL.
Set the computer *L* dials at 2000'.
Use the generated bearing crank to set *B'gr* at 45°.
Turn *Zd* from 800' to 3200'. The *L—L* cos *2B'r* slide should be at its zero position, the position at which there is no movement of the output slide when *Zd* is turned from 800' to 3200'.

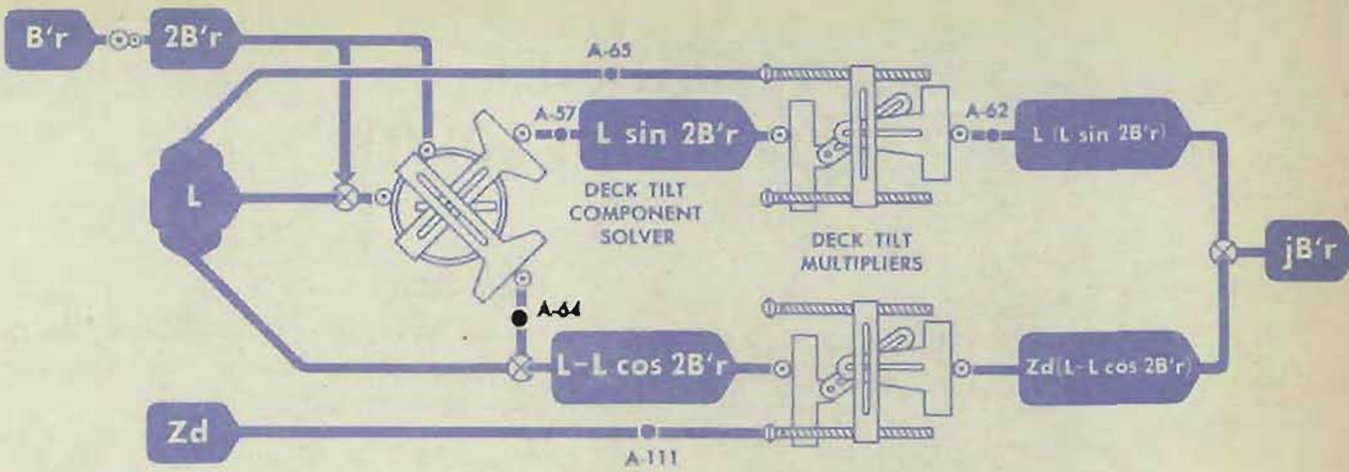
Observe the large output gear on the *jB'r* follow-up to note any movement of the output slide.

Adjustment

If there is movement during the full travel of *Zd*, make A-64 slip-tight.

WARNING: If A-64 is completely loosened, the input slide will fall.

Set *Zd* at 2000' and mark the *jB'r* follow-up output gear.
Turn *Zd* to 3200'.
Use a gear pusher to turn the bevel gear above A-64 until the follow-up output gear has returned to its original mark. Tighten A-64 and recheck by turning *Zd* from 800' to 3200'.
There should be no motion of the *jB'r* follow-up.
Remove all wedges and replace the *Dd* follow-up power leads.
Check A-62.



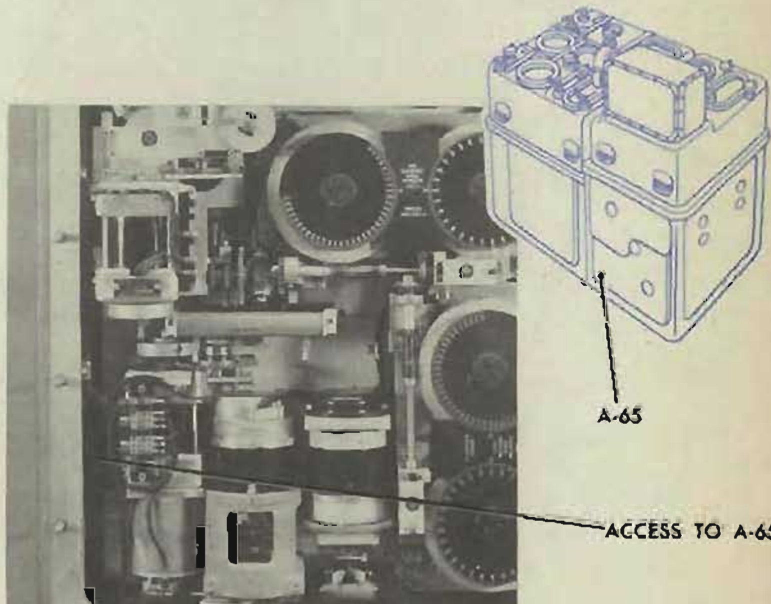
A-65 L (L sin 2B'r) MULTIPLIER to L DIALS

Location

A-65 is a large clamp under cover 6, 8 inches from the bottom and 10 inches in, directly behind the *Eb* follow-up.

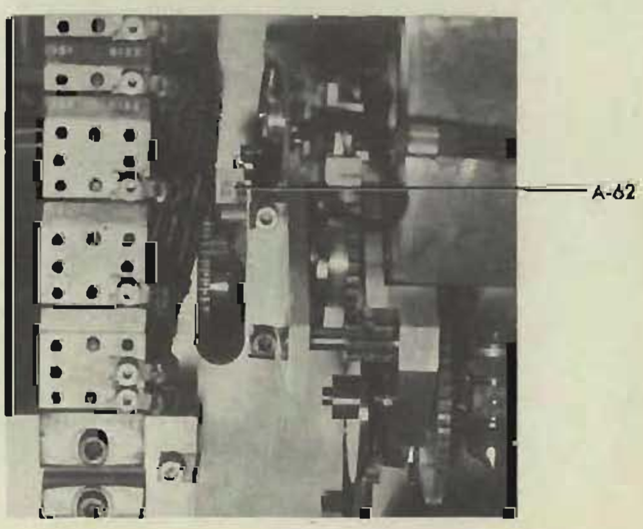
Check

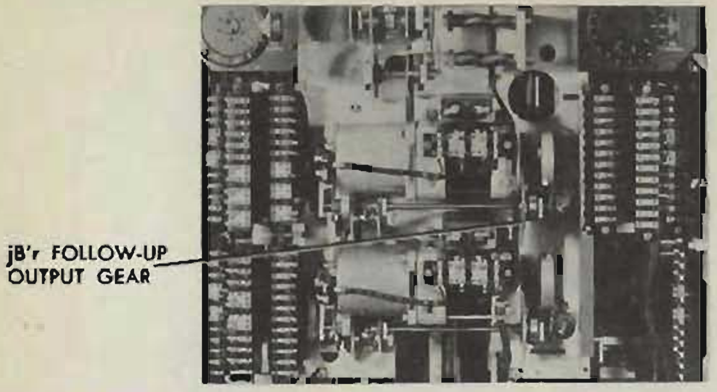
A-57 must be loosened before A-65 can be checked.
Set *L* at 2000'.
Make A-57 slip-tight. See readjustment of A-57.
Use a long gear-pusher to move the *L* sin *2B'r* input rack from limit to limit. Push the gear just behind the A-57 gear.
There should be no motion of the *jB'r* follow-up for full travel of the *L* sin *2B'r* input rack.

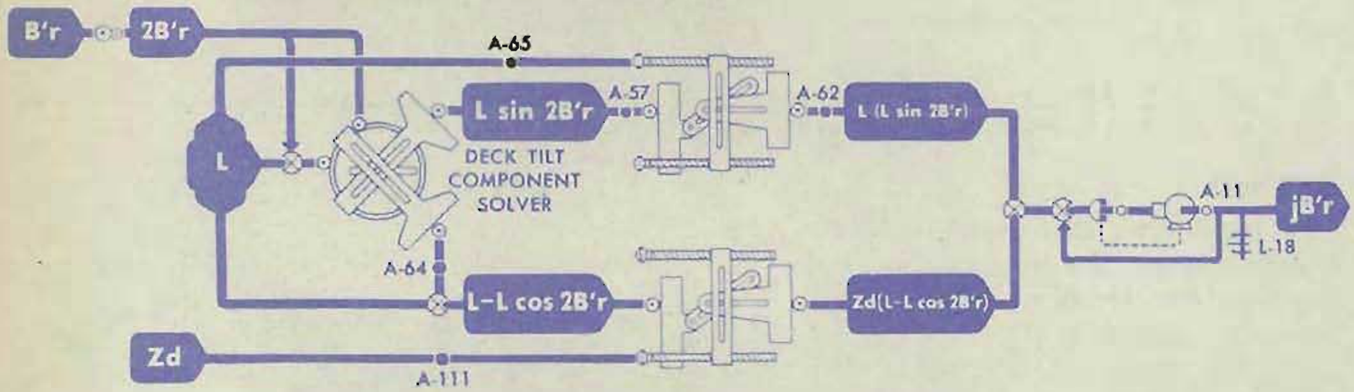


Adjustment

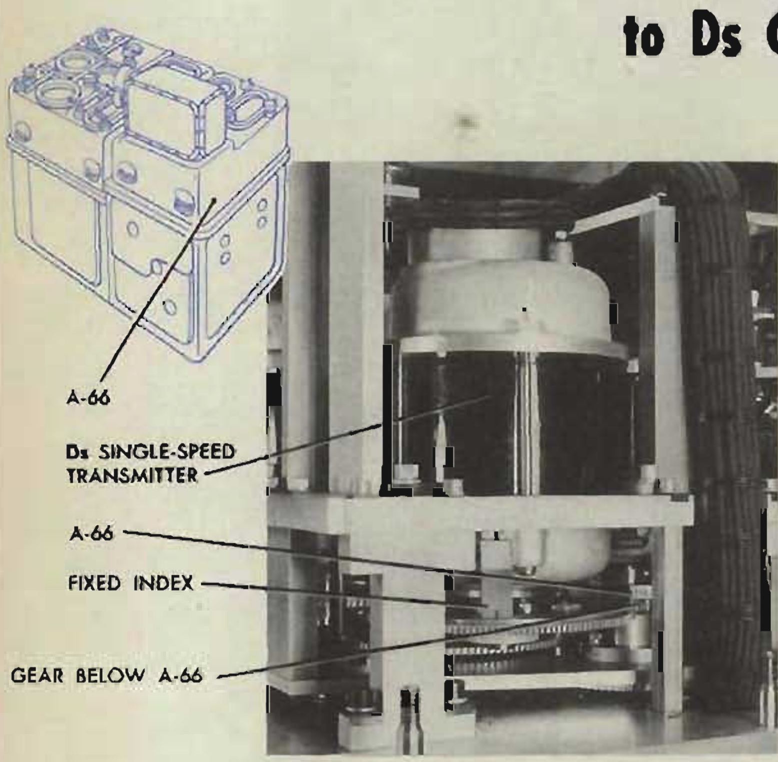
If there is movement of the *jB'r* follow-up, A-65 is in error.
Move the *L* sin *2B'r* input rack to one limit.
Mark the *jB'r* follow-up output friction gear for use as an indicator.
Move the *L* sin *2B'r* input rack to the other limit.
Loosen A-65 and turn the gear next to it to correct halfway.
Make new indicating marks. Continue adjusting until there is no motion of the *jB'r* follow-up for full travel of the *L* sin *2B'r* input rack.
Tighten A-65 and recheck.
Readjust A-57.
Check A-62.







A-66 Ds SINGLE-SPEED TRANSMITTER to Ds COUNTER



Location

A-66 is under cover 2. A-66 is omitted on Mods 1, 3, 4, 8, and 12.

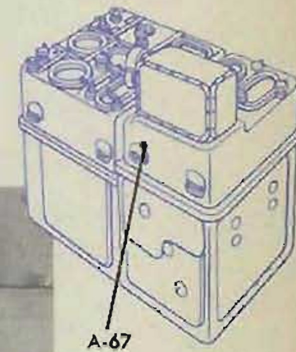
Check

Set the *Ds* counter at 500 mils.
The *Ds* transmitter should be on electrical zero. When the transmitter is on electrical zero, the scribe mark on the rotor gear should match the fixed index.

Adjustment

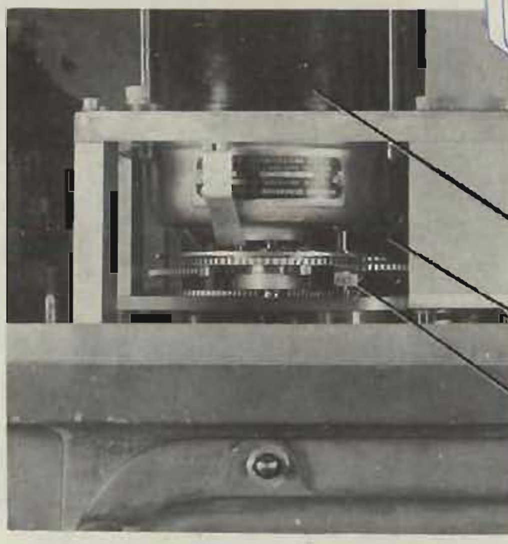
If the transmitter is not on electrical zero, make A-66 slip-tight.
Hold *Ds* at 500.
Turn the gear below A-66 until the scribe mark matches the fixed index.
Tighten A-66, and recheck.
Check A-114, A-94, and A-96.

A-67 COARSE to FINE SYNCHRO— F TRANSMITTER



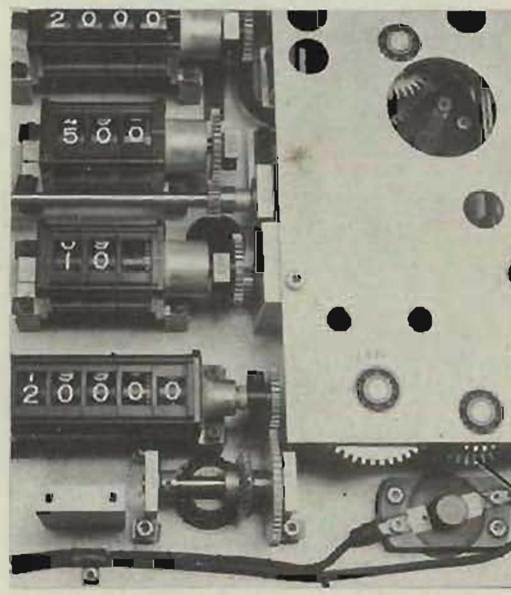
Location

A-67 is under cover 2, at the right front



Check

Set the coarse *F* synchro on electrical zero by turning the *F* input gear. This should also position the fine *F* synchro on electrical zero. When the coarse and fine synchros are on electrical zero, the scribe marks on their rotor gears should be matched with the fixed index marks.

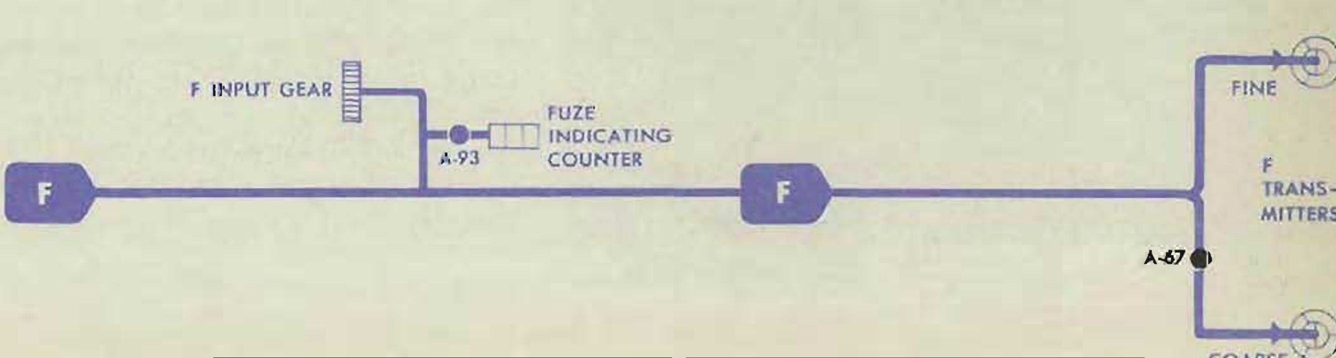


Adjustment

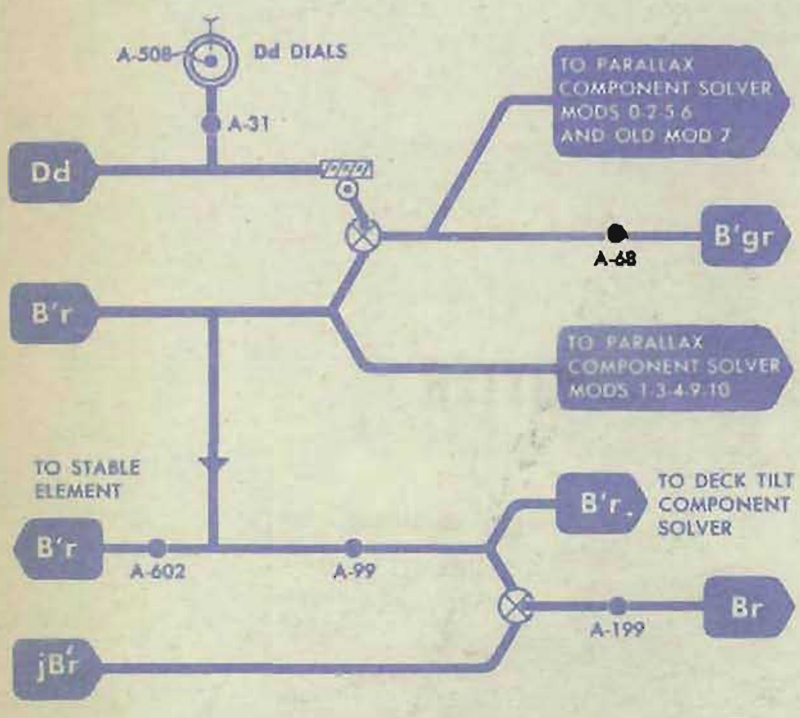
If the rotor of the fine *F* synchro is not on electrical zero, make A-67 slip-tight.

Hold the large gear on the coarse *F* synchro rotor shaft. This will keep the coarse synchro on electrical zero.

Turn the *F* input gear until the rotor of the fine synchro is at electrical zero. Check that the scribe mark on the rotor gear of the coarse synchro still matches its fixed index.
Tighten A-67, and recheck.
Check A-93.



A-68 B'gr DIALS to PARALLAX COMPONENT SOLVER (SER. NOS. 215 and LOWER)



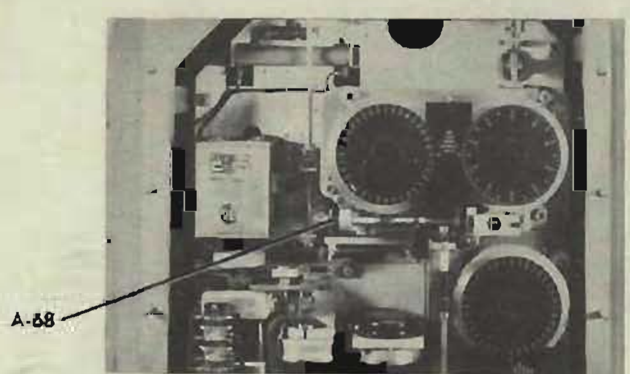
Location

A-68 is under cover 8, on the *B'gr* transmitter gearing.

Check

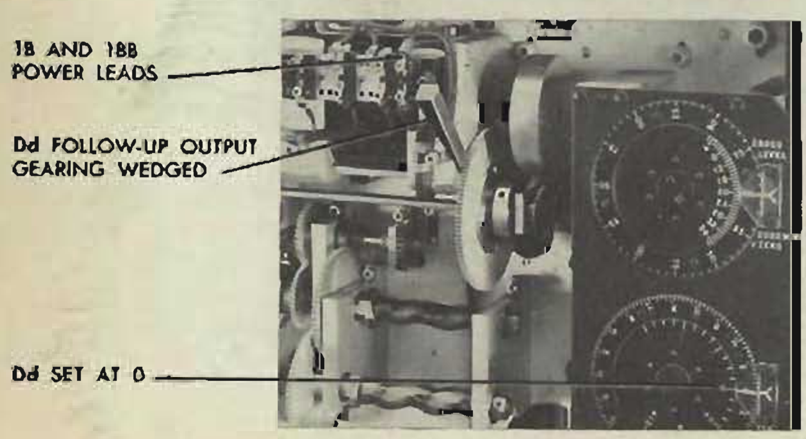
On instruments with Ser. Nos. 215 and lower, A-68 is used to adjust the *B'gr* dials to the parallax component solver. The check and readjustment for A-68 is the same as that given for A-243 on later instruments. Refer to the readjustment of A-243. After readjusting A-68, check A-99.

A-68 ASSEMBLY CLAMP (SER. NOS. 216 and HIGHER)



Check

On instruments with Ser. Nos. 216 and higher, check A-243 and A-99. If one checks correctly, but the other does not, correct the one in error. If both are out of adjustment by an equal amount on the *B'gr* dials, A-68 is upset and should be readjusted.

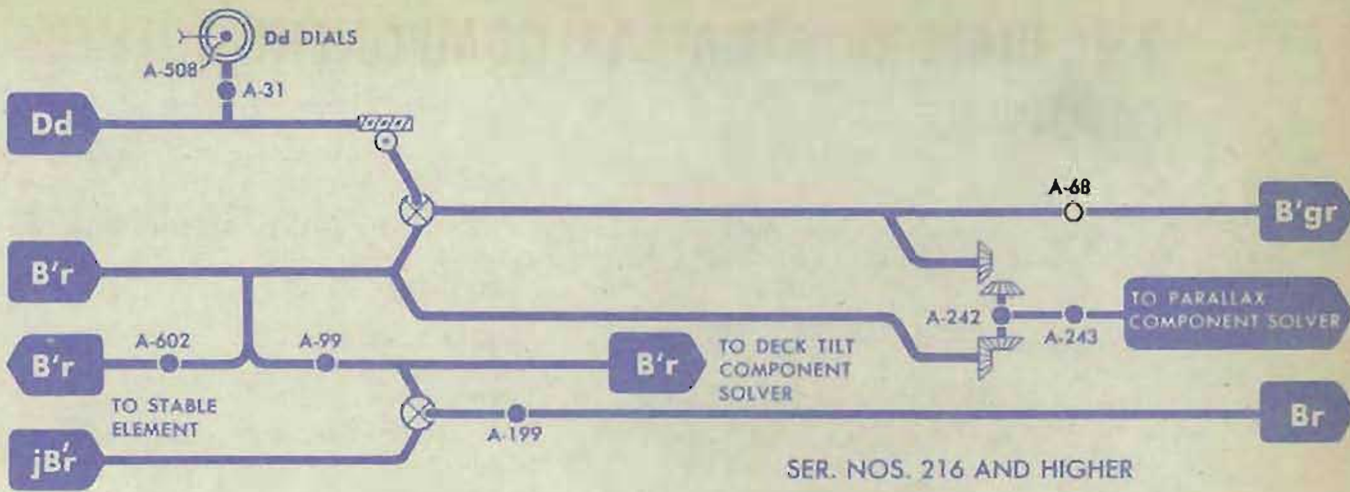


Adjustment

Disconnect leads 1B and 1BB from the *Dd* servo. Wedge the output gearing when the *Dd* dials read 0. Turn the power ON. Turn the control switch to LOCAL. Use the generated bearing crank to set *B'r* at 0°, on the stable element dials.

Loosen A-68. Turn the worm below the *B'gr* transmitter dials to bring the *B'gr* dials to 0°. Split the lost motion and tighten A-68.

Recheck A-243 and A-99.



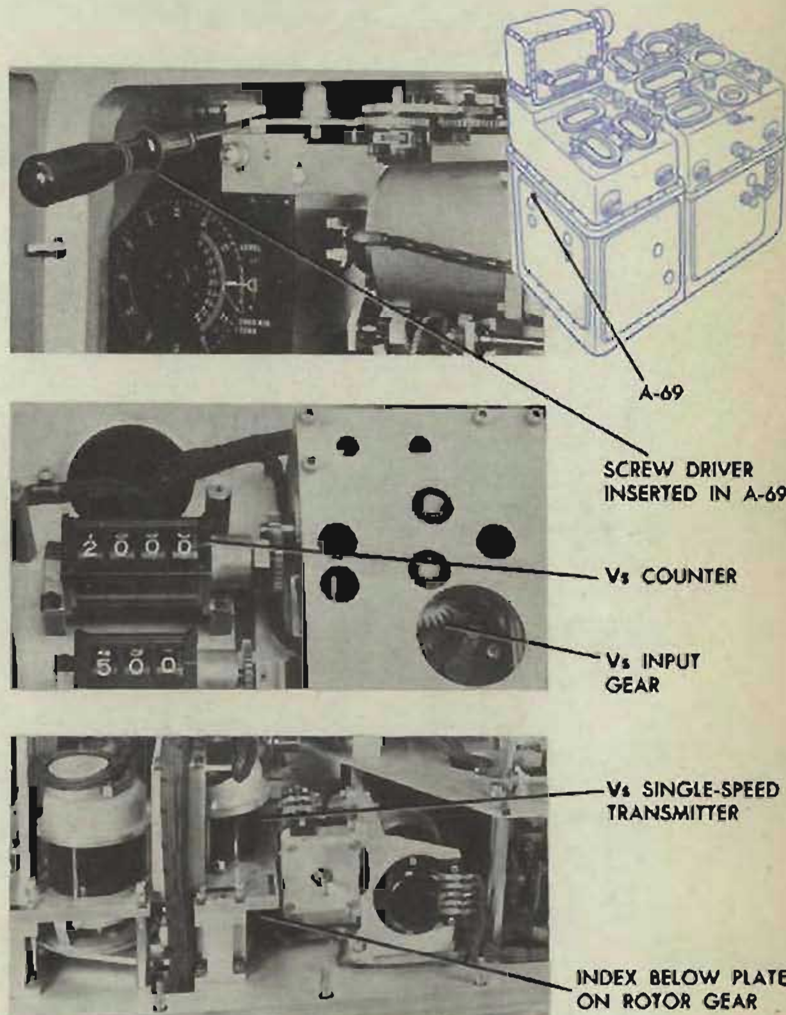
SER. NOS. 216 AND HIGHER

A-69 Vs SINGLE-SPEED TRANSMITTER to Vs COUNTER

Location

A-69 is under cover 7, behind the plate, near the top of the section. It is on the stub shaft below a large spur gear.

A-69 is omitted on Mods 1, 3, 4, 8, and 12.



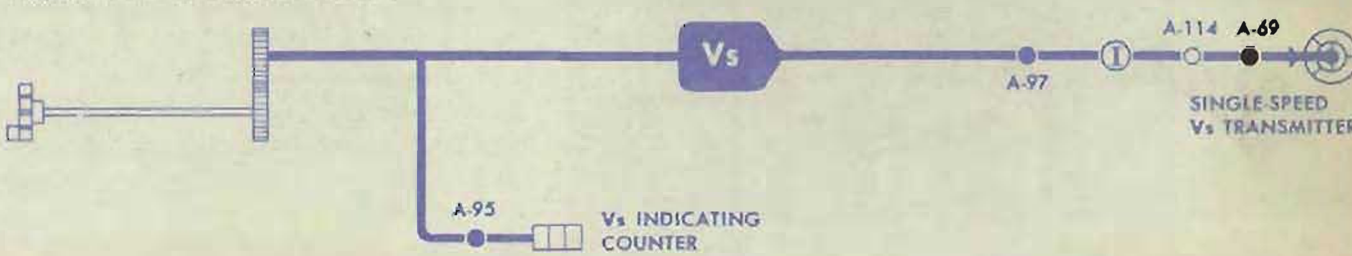
Check

Remove cover 2.
Set the *Vs* counter at 2000′ by turning the *Vs* input gear.

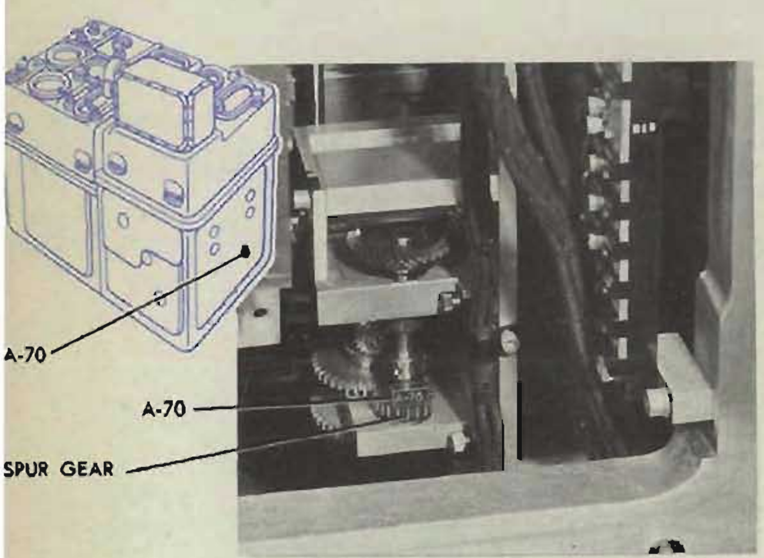
The rotor of the *Vs* single-speed transmitter synchro should be at electrical zero. When the synchro is at electrical zero, the scribe mark on the rotor gear should match the fixed index.

Adjustment

If the synchro is not on electrical zero, make A-69 slip-tight. Hold *Vs* at 2000′. Turn the large gear on the rotor of the synchro until the scribe mark matches the fixed index.
Tighten A-69 and recheck.



A-70 SYNCHRONIZING THE B'r LOCAL CONTROL FOLLOW-UP



Location

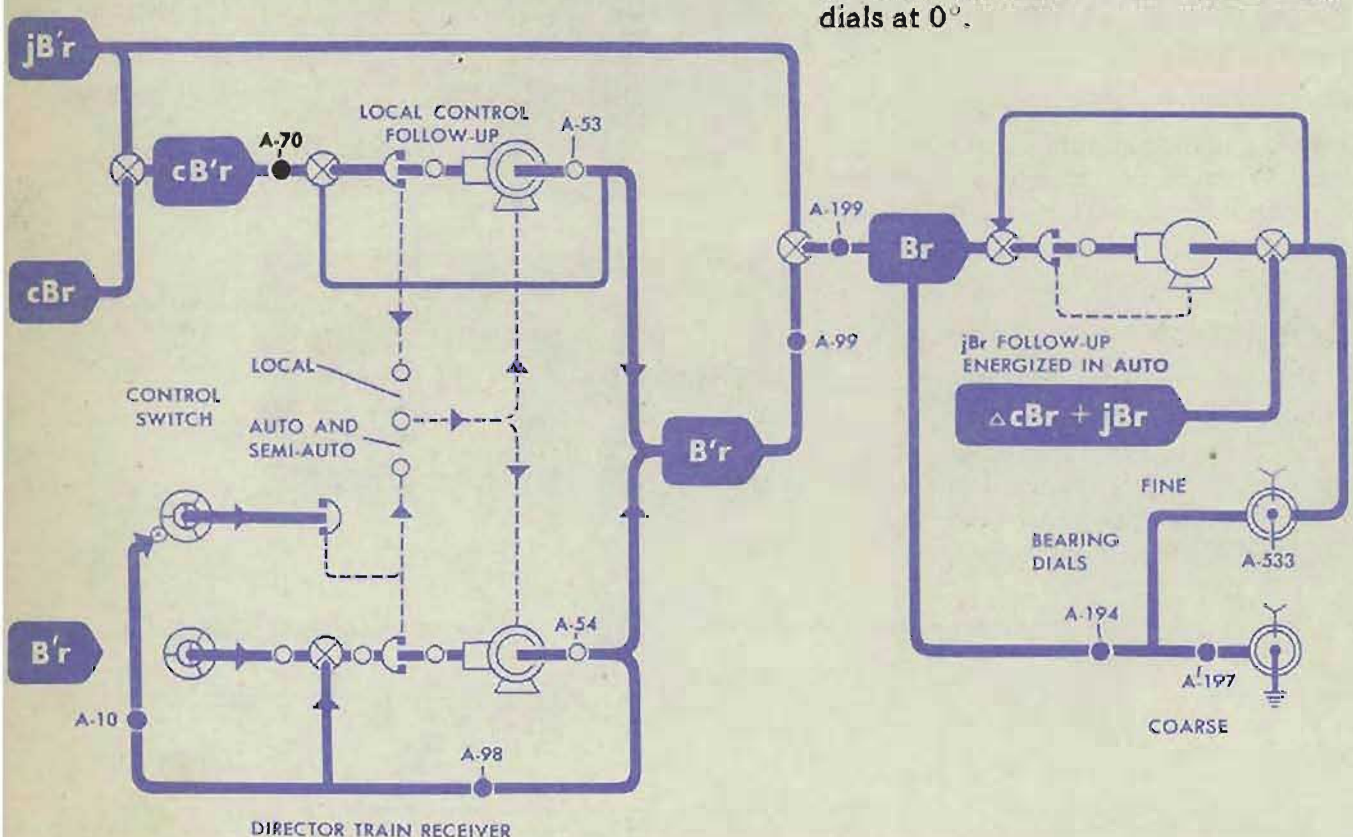
A-70 is under cover 7, in line with the *Zd* input shaft.

Check

Turn the power ON.
Turn the control switch to LOCAL to energize the *B'r* local control follow-up.
At the switchboard, turn the director train receiver switch OFF.
Turn the control switch to AUTO.
There should be no motion of the inner bearing dial.
If the inner bearing dial moves when the control switch is turned from LOCAL to AUTO, the *B'r* local control follow-up is not properly adjusted.

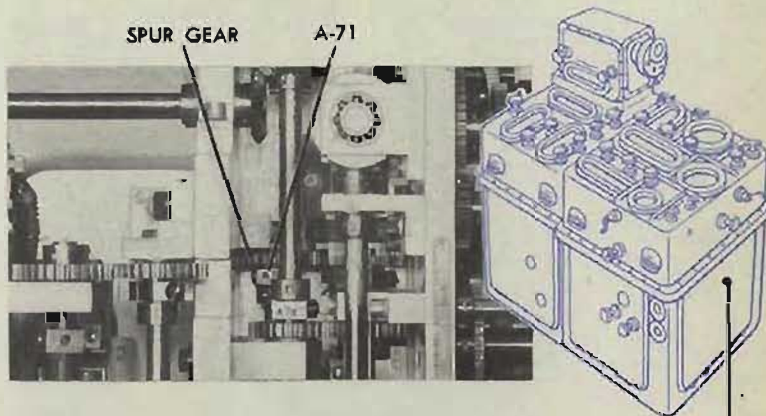
Adjustment

Make A-70 slip-tight.
Turn the control switch to LOCAL.
Turn the generated bearing crank in its OUT position to set the *Br* ring dials at 0°.



Turn the control switch to AUTO.
After the inner dial stops, turn the control switch back to LOCAL. Turn the spur gear below A-70 to put the ring dials back to 0°. Tighten A-70. Check by turning the control switch back and forth between AUTO and LOCAL, making sure that *B'r* is cut off at the fire control switchboard.
Check A-533.

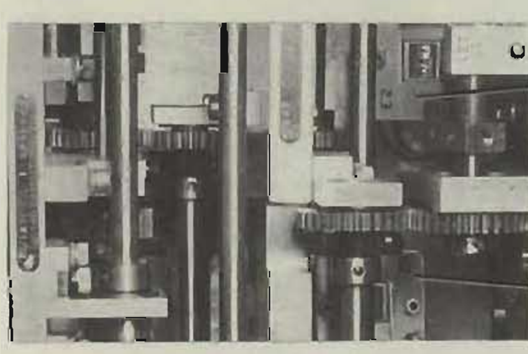
A-71 Tf/R2 BALLISTIC COMPUTER to E2 MASTER COUNTER



Location

A-71 is under cover 4.

The *E2* master counter is directly below the *E2* counter in the *Tf/R2* ballistic computer.

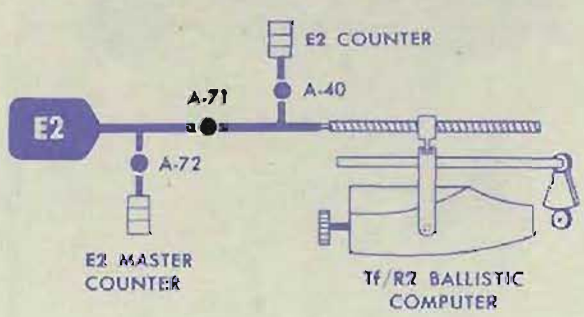


Check

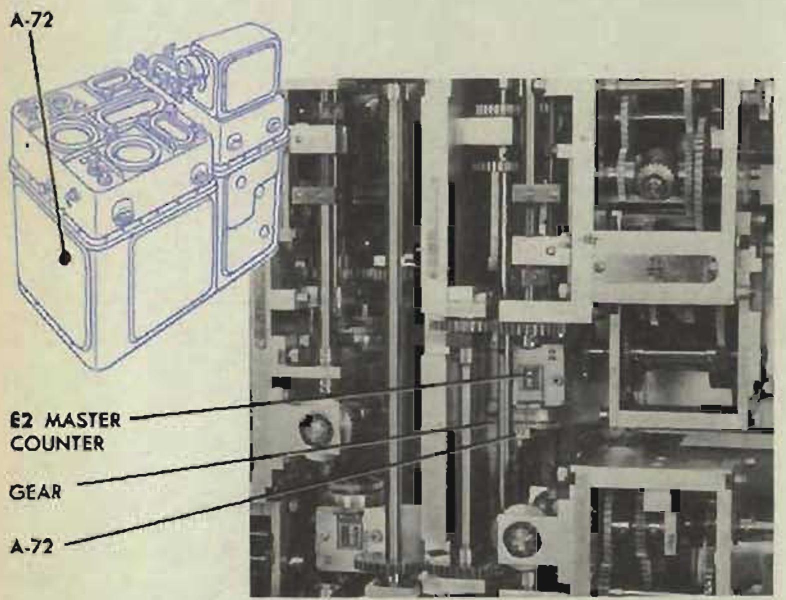
Both *E2* counters should agree.

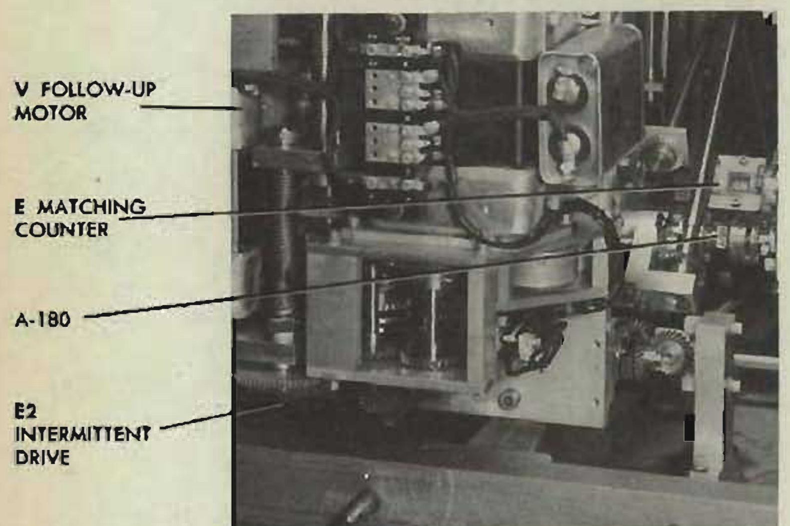
Adjustment

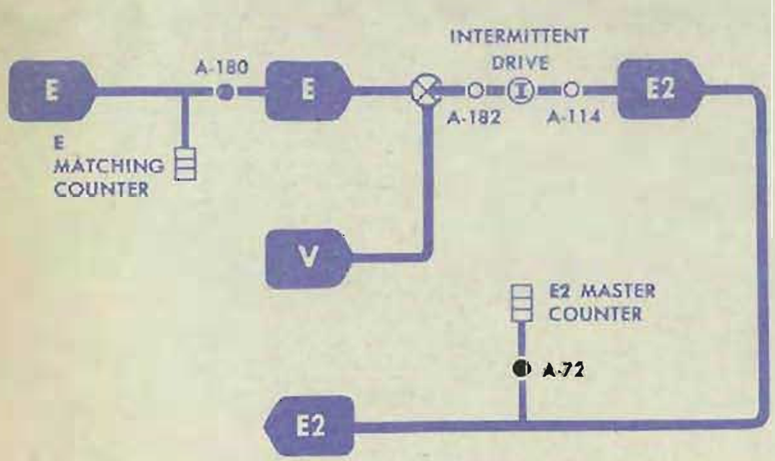
If the counters do not agree, make A-71 slip-tight. Hold the master counter, and turn the spur gear above A-71 to make the counter in the ballistic computer agree.
Tighten A-71 and recheck.



A-72 E2 MASTER COUNTER to E2 INTERMITTENT DRIVE







Location

A-72 is under cover 4, at the upper left of the fuze ballistic computer, below the *E2* master counter.

The *E2* intermittent drive is under cover 5, behind the lower front corner of the *V* follow-up mounting plate.

Check

Set *Vs* at 2000′.
Use the sync *E* handcrank in its CENTER position to decrease *E* until the *E2* master counter stops turning. When the master counter stops turning, the *E2* intermittent drive has reached its low cut-out point.
The *E2* counter reading should be 0°.

Adjustment

If the *E2* counter reading at the lower cut-out point is not 0°, loosen A-72. Use a gear pusher to turn the gear above the clamp, until the counter reads 0°.
Tighten A-72.

Recheck

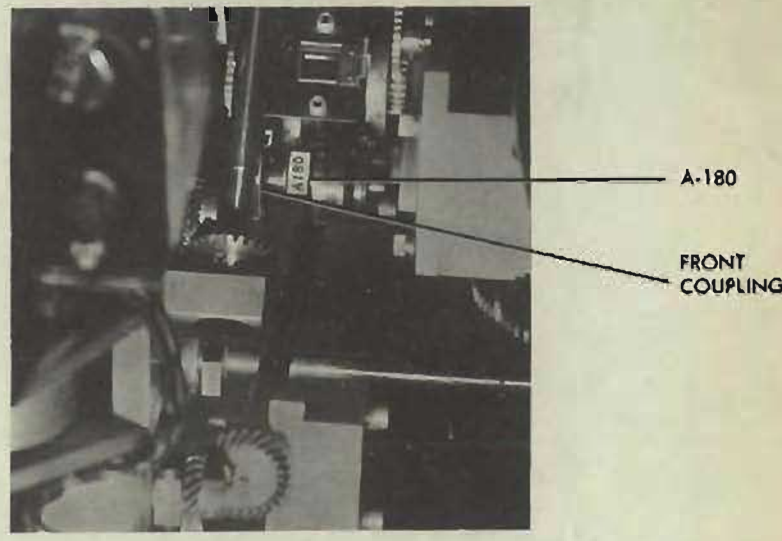
Increase *E* and *Vs* until the *E2* counter stops turning. This is the high cut-out point of the intermittent drive. The *E2* counter should read 90°.

IMPORTANT

1 If the limit stops on the *E* and *V* lines operate before the low cut-out point of the intermittent drive is reached, loosen A-180. Hold the coupling at the front of the clamp and increase *E* to 85°.

Tighten A-180 and decrease *E* until the intermittent drive reaches its low cut-out point. If the cut-out point still cannot be reached, this procedure may have to be repeated several times.

A-180 is located under cover 5, on the coupling immediately below the *E* matching counter.



2 If interference on the *E2* line keeps the intermittent drive from reaching either limit, check A-85, A-73, A-71, and A-84 (the *E2* lead screw inputs of the four ballistic computers). Check A-107 (the *E2* cam of the complementary error corrector). Check A-106 (the vector gear of the elevation wind component solver). Check A-183 (the *E2* line to the parallax and trunnion tilt sections). Determine which clamp is causing the restriction and loosen it.

Readjust A-180 and any other clamps that were loosened. Check A-182, A-114, A-71, A-73, A-84, A-85, A-106, A-107, and A-183.

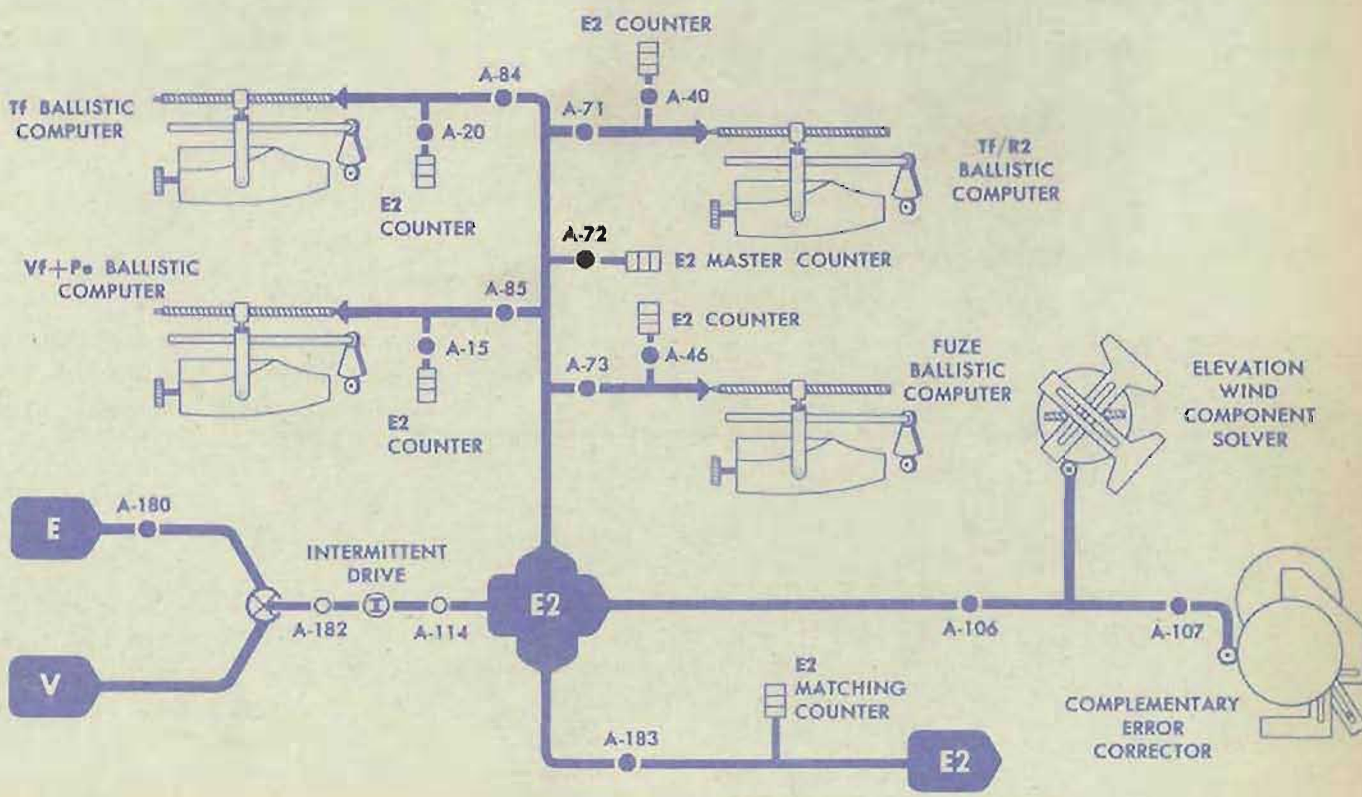
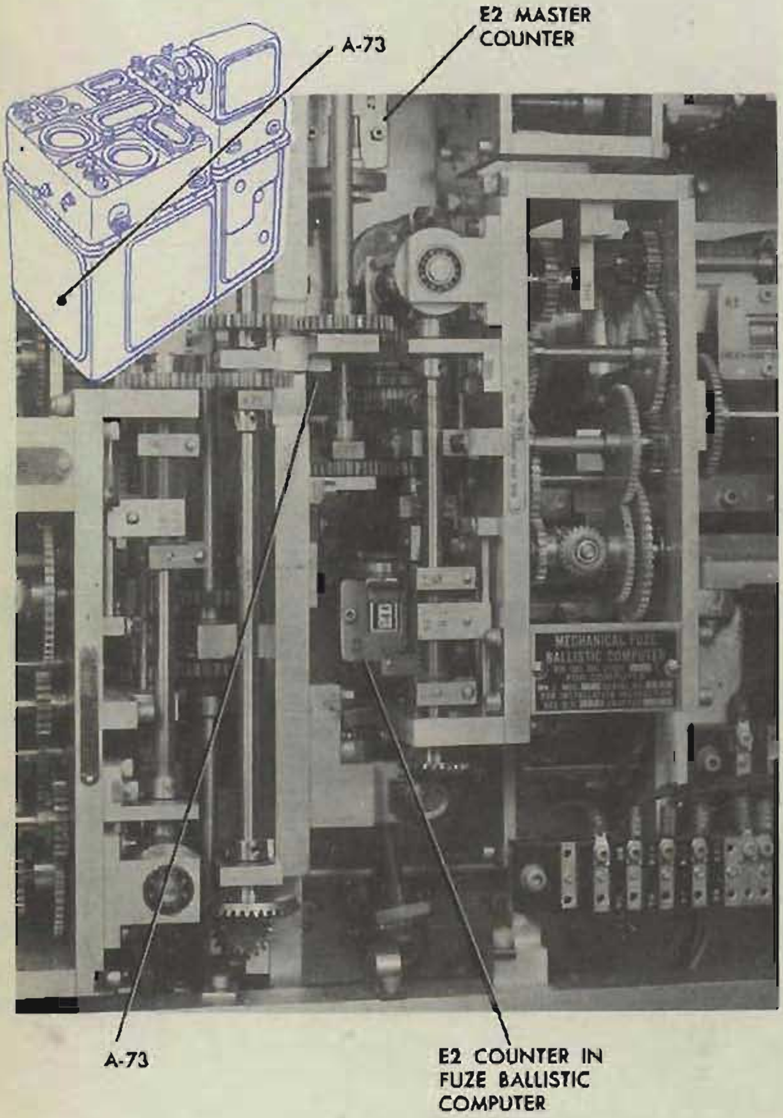


Table of Contents

A-73 F BALLISTIC COMPUTER to E2 MASTER COUNTER



Location

A-73 is under cover 4, between the *Vf* + *Pe* and the fuze ballistic computers, behind clamp A-77.

Check

The *E2* counter in the fuze ballistic computer should agree with the *E2* master counter.

Adjustment

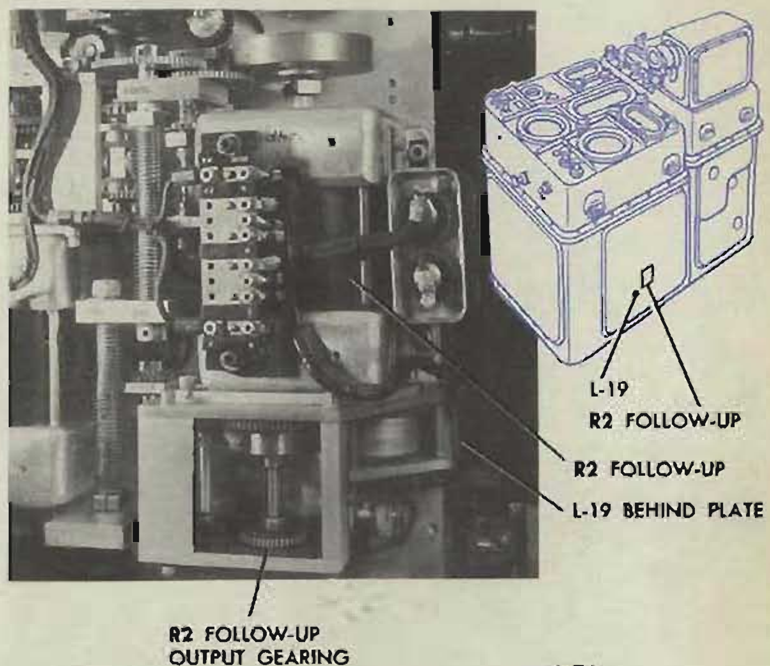
If the counters do not agree, loosen A-73. Turn the spur gear below the clamp until the *E2* counter in the fuze ballistic computer agrees with the *E2* master counter.

Tighten A-73 and recheck.

A-74 R2 MASTER COUNTER to L-19

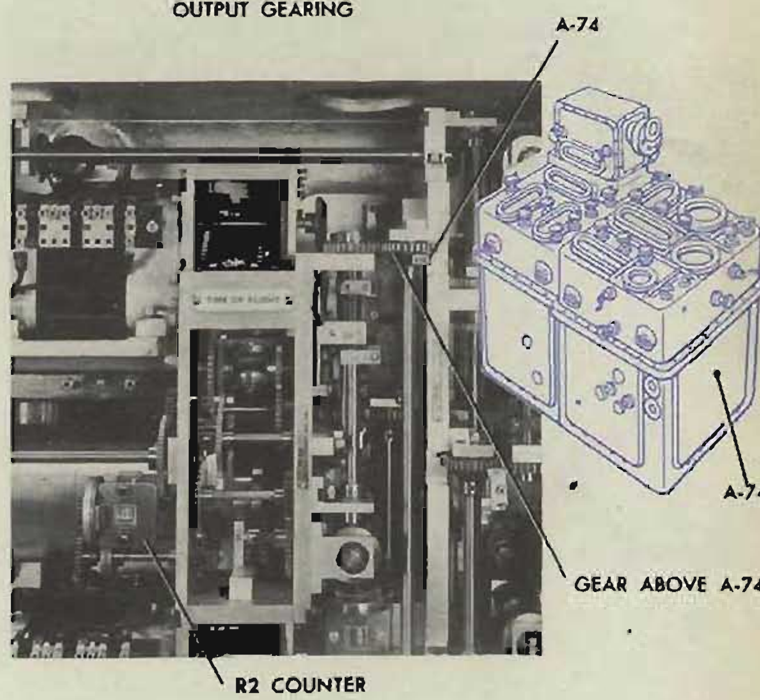
Location

A-74 is under cover 4, above and to the right of the *Tf* ballistic computer. L-19 is under cover 5, behind the *R2* follow-up mounting plate. It is in a horizontal position with its lower limit toward the front.



Check

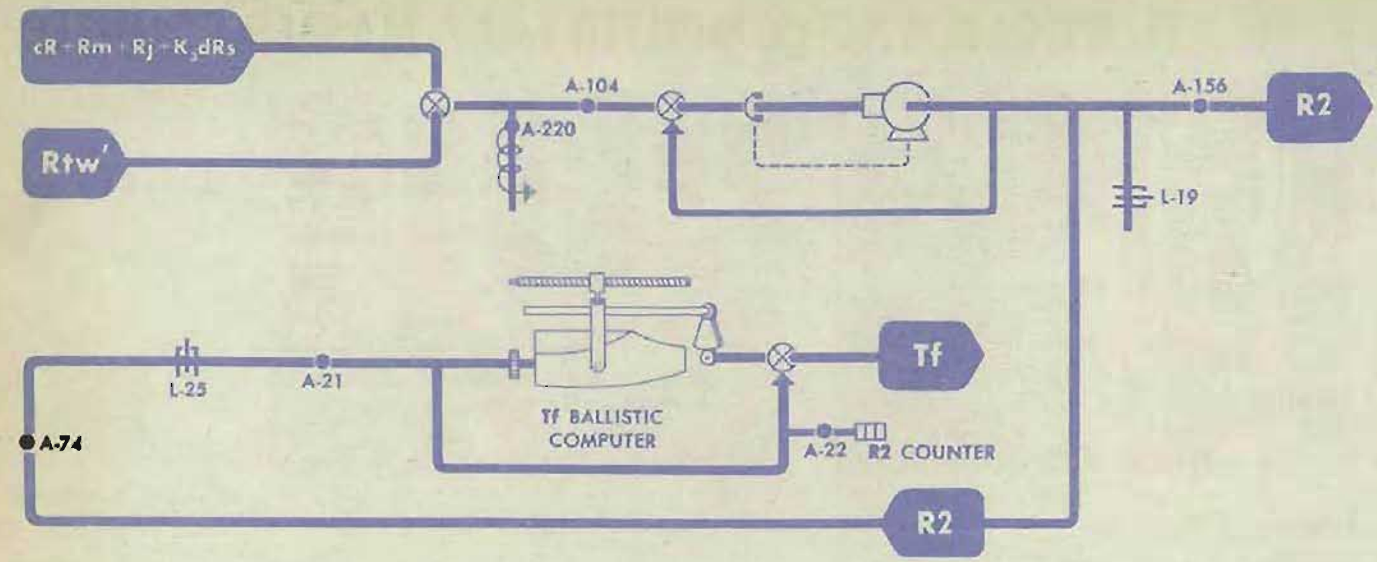
Turn the power OFF.
Turn the *R2* follow-up output gearing to run *R2* to the upper limit.
The *R2* master counter should read 18,000 yards (180) on Mods 0 through 7, 9, 10, and 13.
On Mods 8 and 12, the upper limit of *R2* is 20,000 yards (200).
Turn the gearing to run *R2* to the lower limit. The *R2* master counter should read 500 yards (005) on Mods 3-7, 8, 10, 12, and 13.
On Mods 0, 1, 2, and 9, the lower limit is 1500 yards (015).



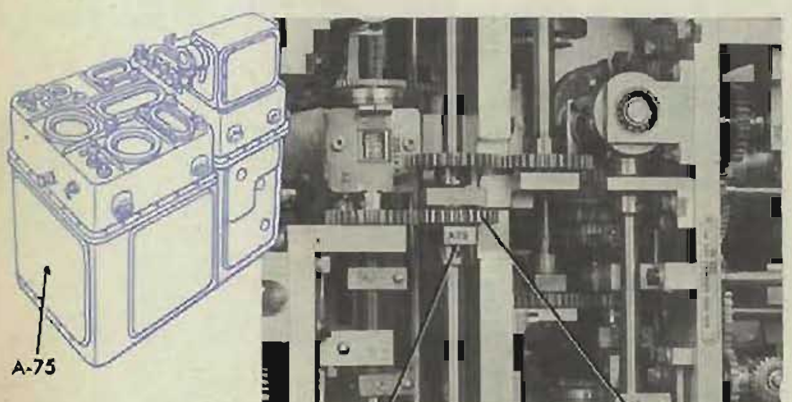
Adjustment

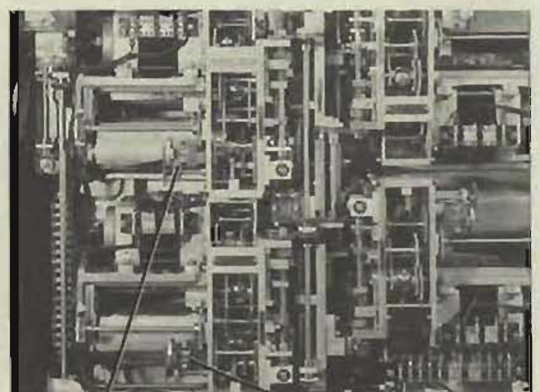
If the *R2* master counter does not read correctly, loosen A-74. Hold the shaft below A-74 to keep the line against the stop. Turn the gear above A-74 until the *R2* master counter reads correctly. Tighten A-74. Recheck the limits.
Readjust any clamps that were loosened. Check A-75, A-76, A-203, A-156, A-92, and A-104.

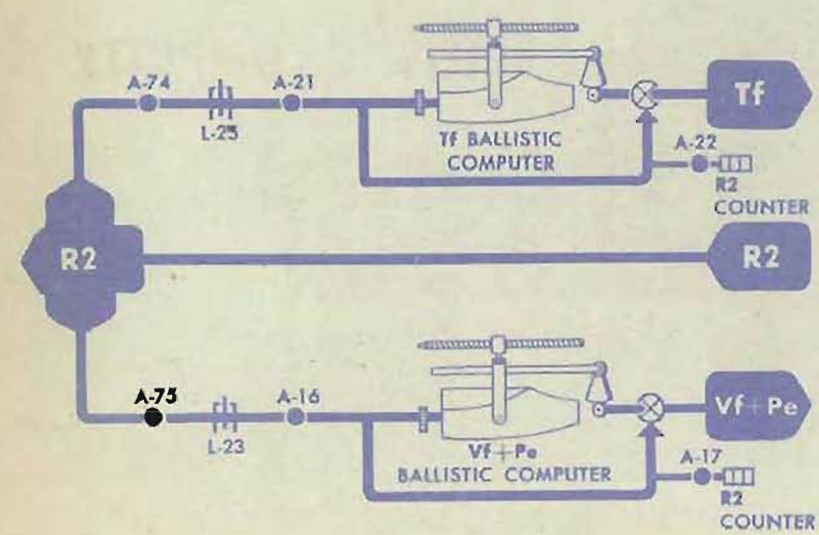
Table of Contents



A-75 Vf + Pe BALLISTIC COMPUTER to R2 MASTER COUNTER







Location

A-75 is under cover 4, to the right of the *Vf* + *Pe* ballistic computer.

Check

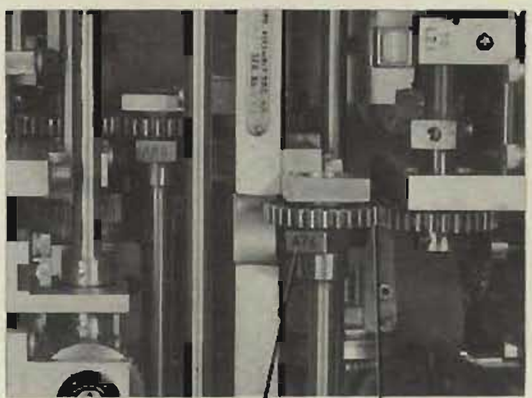
The *R2* counters in the *Tf* and *Vf* + *Pe* computers should agree.

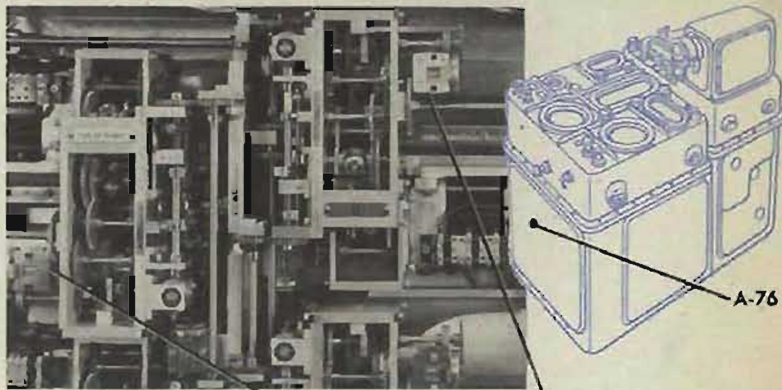
Adjustment

If the counters do not agree, make A-75 slip-tight. Turn the spur gear above the clamp until the counters agree.

Tighten A-75 and recheck.

A-76 Tf/R2 BALLISTIC COMPUTER to R2 MASTER COUNTER





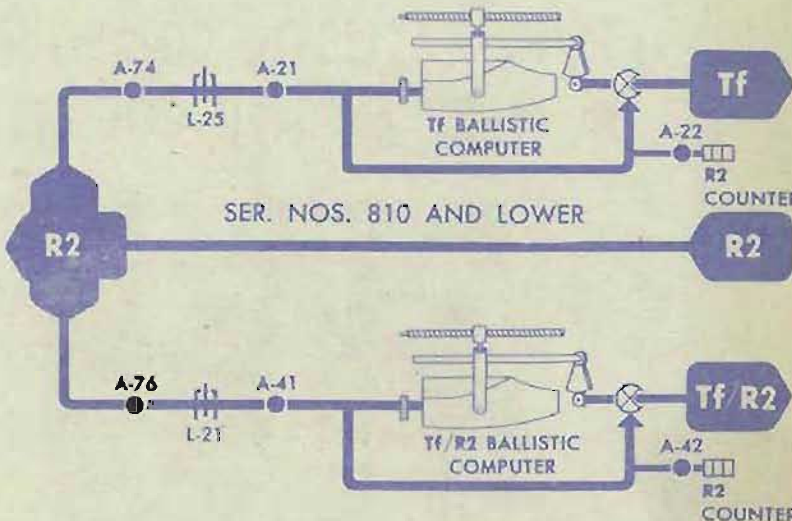
Location

A-76 is under cover 4, to the left of the *Tf/R2* ballistic computer.

Check

On Ser. Nos. 810 and lower, the *R2* counter in the *Tf/R2* ballistic computer should agree with the *R2* master counter in the *Tf* ballistic computer unless an offset has been purposely introduced per Bureau of Ordnance Information Bulletin 4-44.

On Ser. Nos. 811 and higher, set front *I.V.* at 2550 f.s. Then the *R2m* counter in the *Tf/R2* ballistic computer should agree with the *R2* master counter.



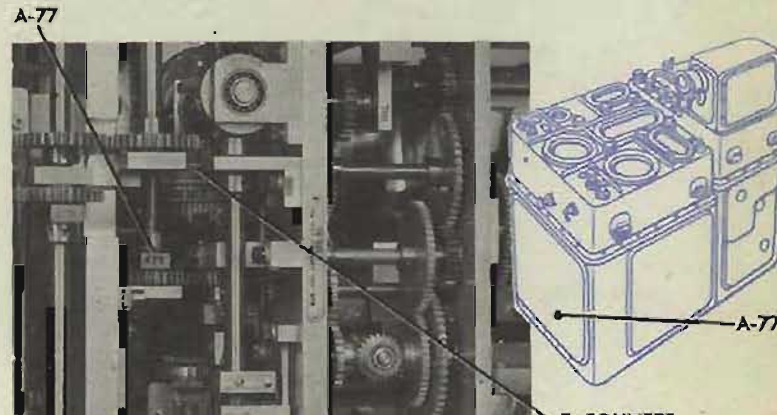
Adjustment

If the counters do not agree, make A-76 slip-tight.

Turn the spur gear above the clamp until the counters agree.

Tighten A-76 and recheck.

A-77 F INDICATING COUNTER to F BALLISTIC COMPUTER

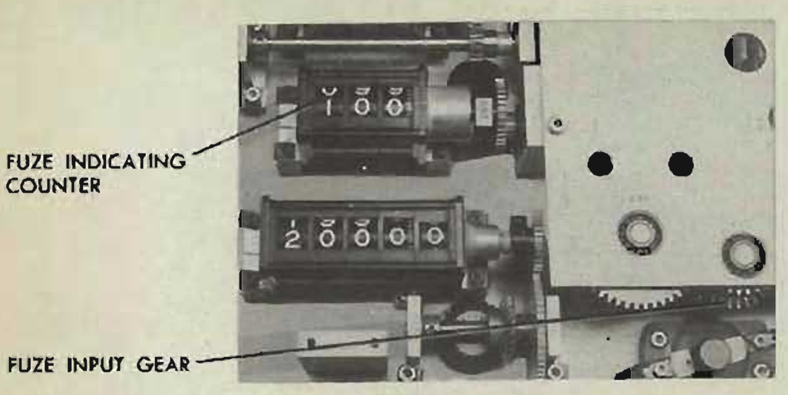


Location

A-77 is under cover 4, on the left side of the fuze ballistic computer. The *F* counter is in the *F* ballistic computer. The *F* indicating counter is under cover 2.

Check

Both *F* counters should agree.

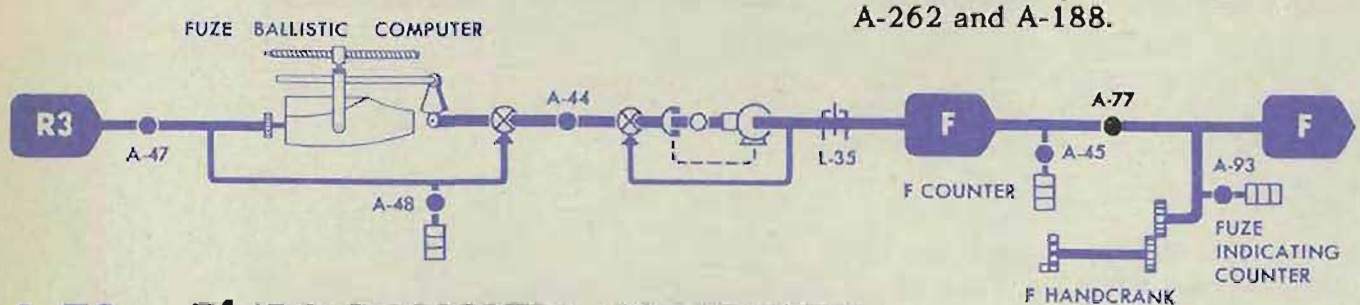


Adjustment

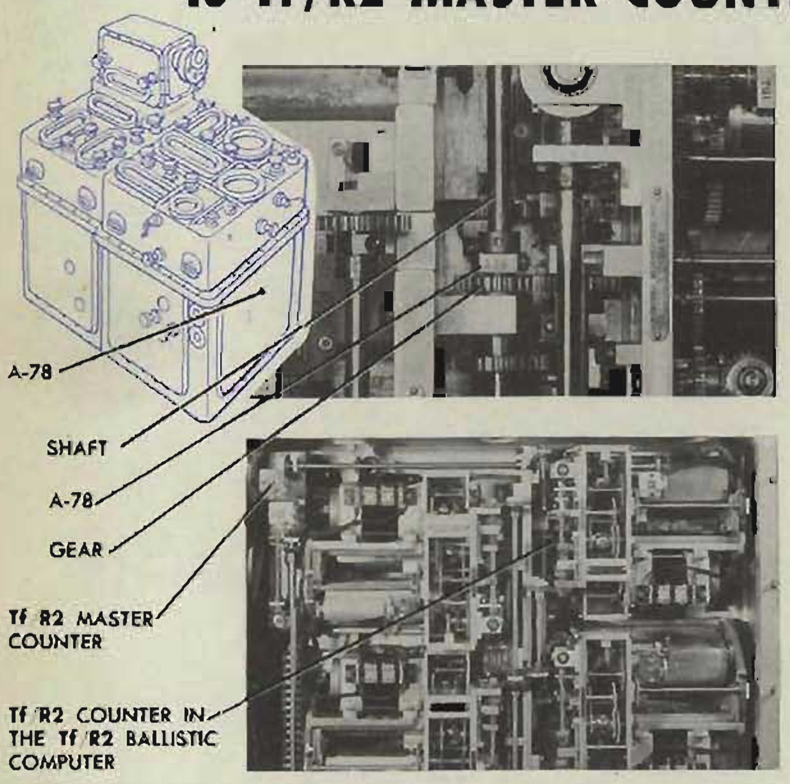
If the counters do not agree, check A-93. Make A-77 slip-tight.

Use the *F* handcrank to bring the *F* indicating counter to the same reading as the fuze ballistic computer counter.

Tighten A-77 and recheck.
On Ser. Nos. 781 and higher, check A-262 and A-188.



A-78 Tf/R2 BALLISTIC COMPUTER to Tf/R2 MASTER COUNTER



Location

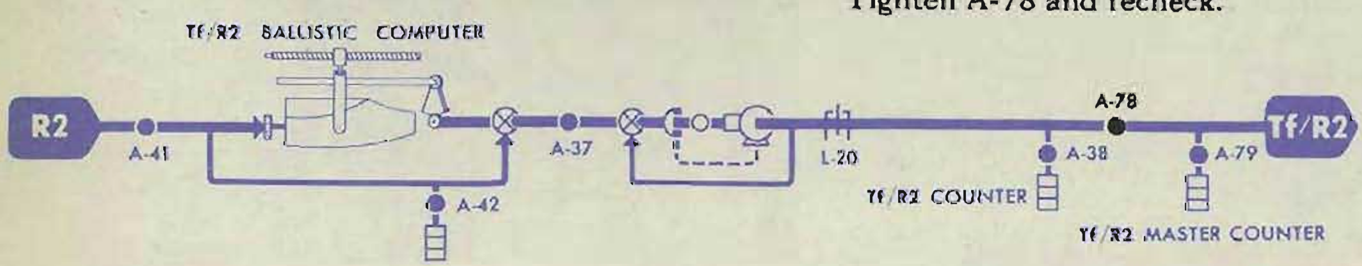
A-78 is under cover 4.
Both *Tf/R2* counters are under cover 4.

Check

Both *Tf/R2* counters should agree.

Adjustment

If the counters do not agree, make A-78 slip-tight.
Hold the spur gear below A-78 and turn the shaft until the *Tf/R2* master counter matches the ballistic counter.
Tighten A-78 and recheck.



A-79 Tf/R2 MASTER COUNTER to ELEVATION PREDICTION MULTIPLIER

Location

A-79 is under cover 4, below the gear on the drum of the *Tf/R2* master counter.

IMPORTANT

Before this counter can be set at the check value, A-78 and A-133 must be loosened.

Check

Set the *Tf/R2* counter at 0.00115 by turning the shaft line to the counter. The lead screw of the elevation prediction multiplier should now be in a position where full travel of the *RdE* $-K_1WrE$ input rack will cause no movement of the *Vtw'* output rack.

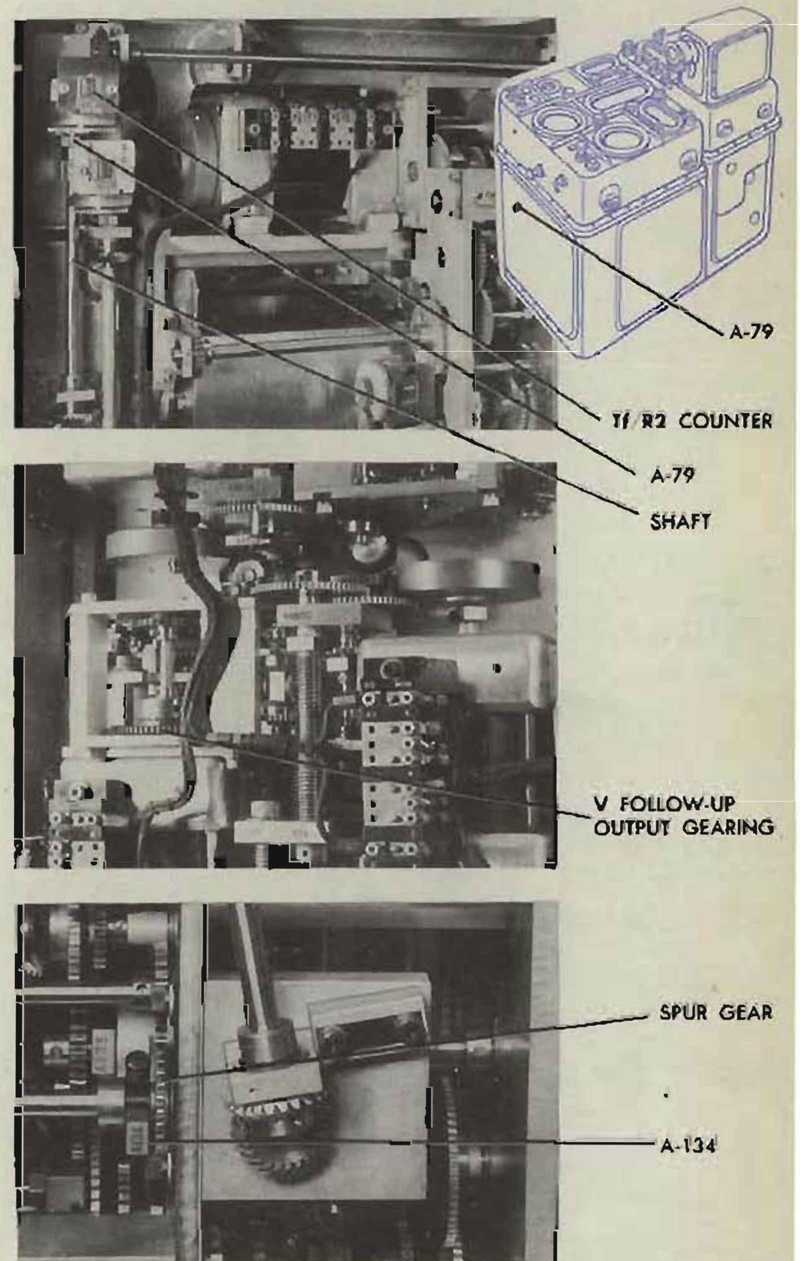
Turn the power ON.
Pull the *Vs* handcrank OUT.
Loosen A-134 and turn the spur gear next to the clamp to run the *RdE* $-K_1WrE$ rack from limit to limit. Motion of the *V* follow-up output gearing indicates movement of the *Vtw'* output rack.

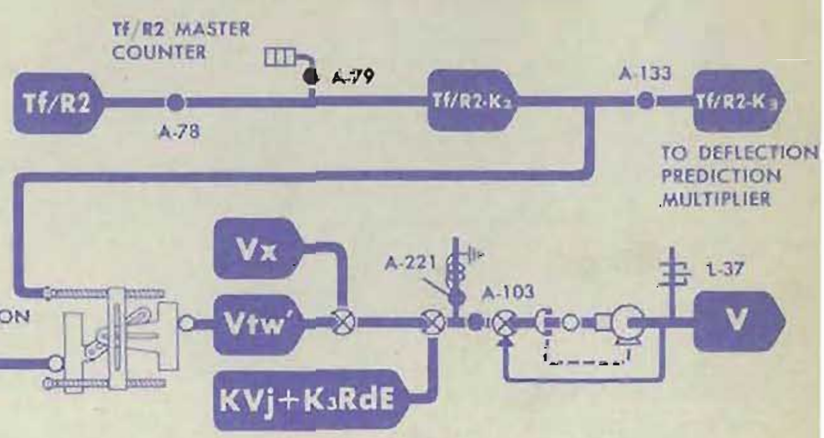
Adjustment

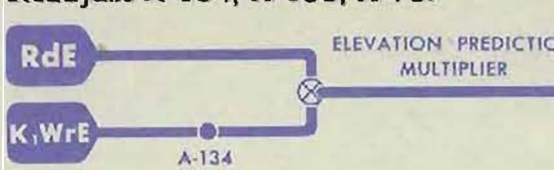
If the *V* follow-up output gearing moves, make A-79 slip-tight. Gently turn the shaft below A-79 until the multiplier lead screw is at its lower limit. Hold the shaft against the lower limit and slip the *Tf/R2* counter to 0.001095.
Turn the shaft until the *Tf/R2* counter again reads 0.00115.

Repeat the check.

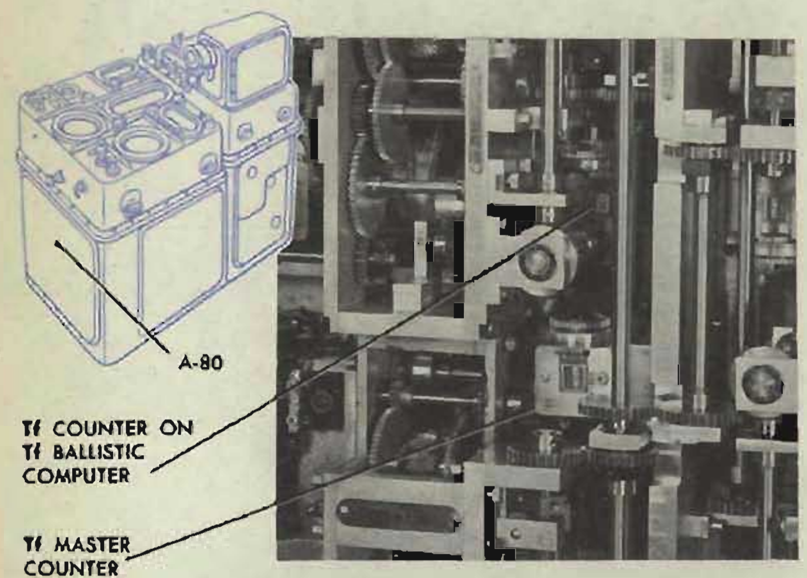
If the adjustment is still off, correct slightly by turning the shaft below A-79 until the *Tf/R2* input screw is at its zero position. This is the position at which full travel of the *RdE* $-K_1WrE$ input rack produces no movement of the *V* follow-up output gearing. Hold the *Tf/R2* input shaft and reset the counter at 0.00115.
Tighten A-79 and recheck.
Readjust A-134, A-133, A-78.

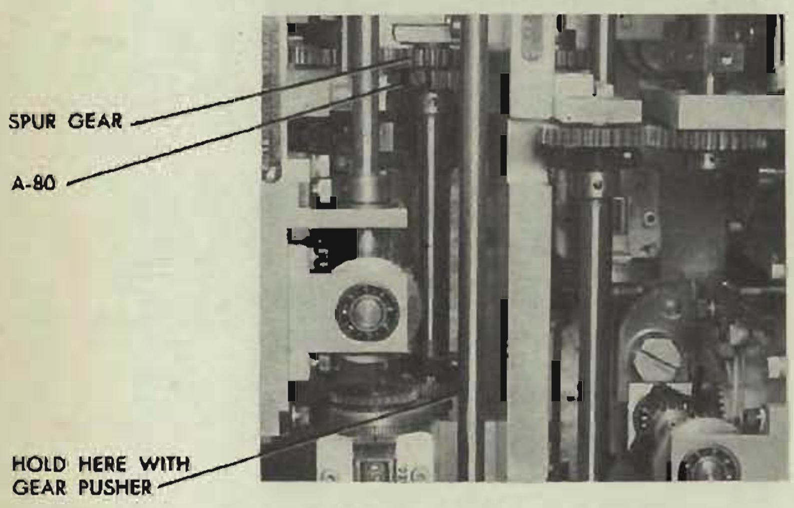






A-80 Tf BALLISTIC COMPUTER to Tf MASTER COUNTER





Location

A-80 is under cover 4, to the right of the *Tf* ballistic computer.

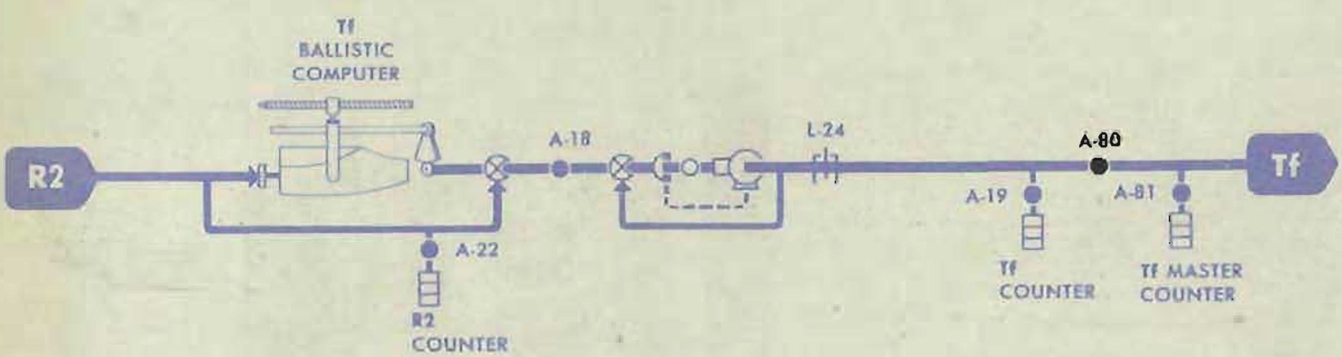
Check

The *Tf* master counter and the *Tf* ballistic counter should agree.

Adjustment

If the counters do not agree, make A-80 slip-tight. Turn the spur gear above the clamp until the *Tf* counter in the ballistic computer agrees with the *Tf* master counter.

Tighten A-80 and recheck.



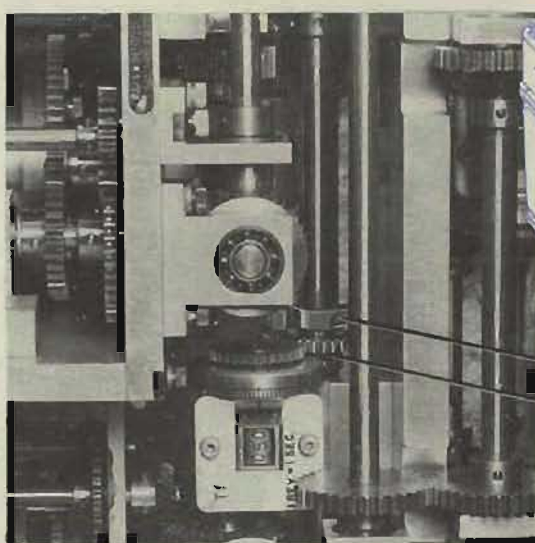
A-81 Tf MASTER COUNTER to RANGE PREDICTION MULTIPLIER

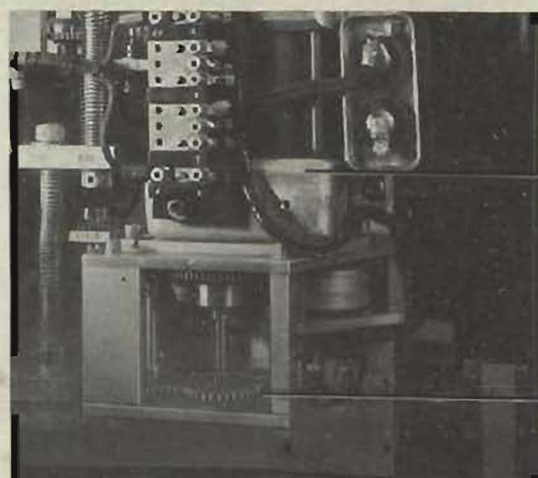
Location

A-81 is under cover 4, at the lower right of the *Tf* ballistic computer, above the *Tf* counter.

Check

Remove leads A and AA from the *Tf* follow-up.
Turn the power ON.
Set the *Tf* counter at 5 seconds (050) by turning the shaft line leading to the counter. On Mods 8 and 12, set *Tf* at 8 seconds (080).
Wedge the line.
The lead screw input of the range prediction multiplier should now be positioned so that movement of the $K\ (dR_s + K_1W_rR)$ input rack causes no movement of the *Rtw'* output rack. To move the input rack, A-135 must be loosened and readjusted later.
The *R2* follow-up gearing indicates *Rtw'* output.
Make indicating marks on the *R2* follow-up output gearing.
Turn the small gear behind A-135 to move the input rack from limit to limit.
The indicating marks should remain matched.

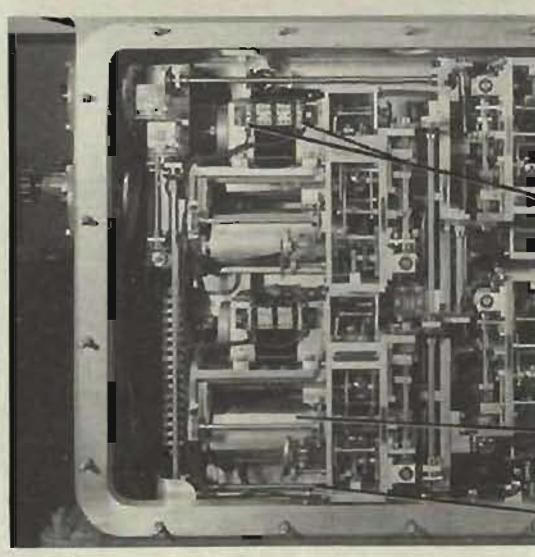




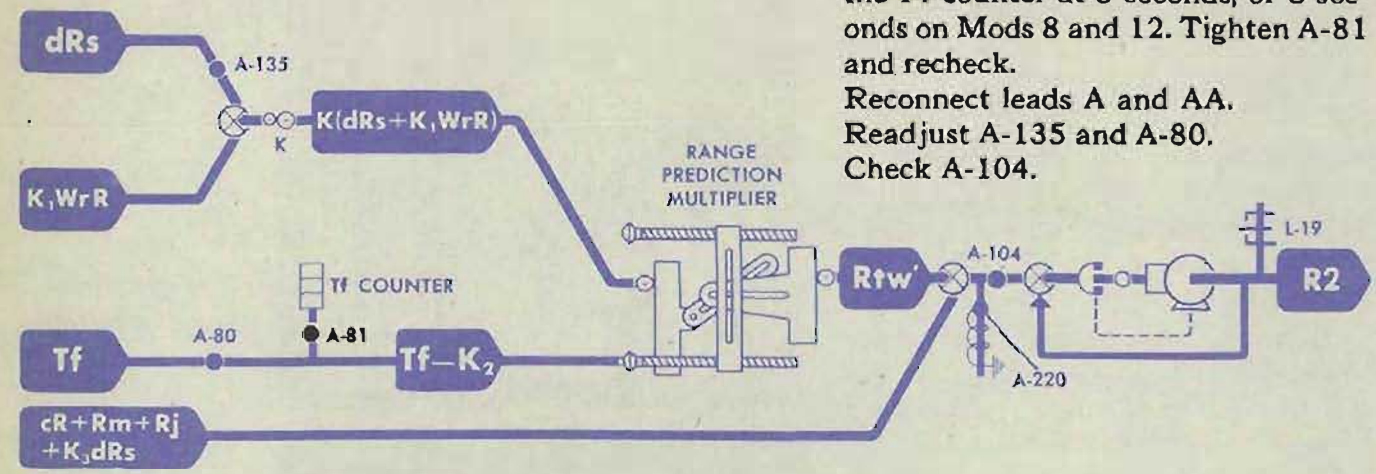
Adjustment

If there is motion of the *R2* follow-up output gearing, the lead screw input can be set approximately as follows:

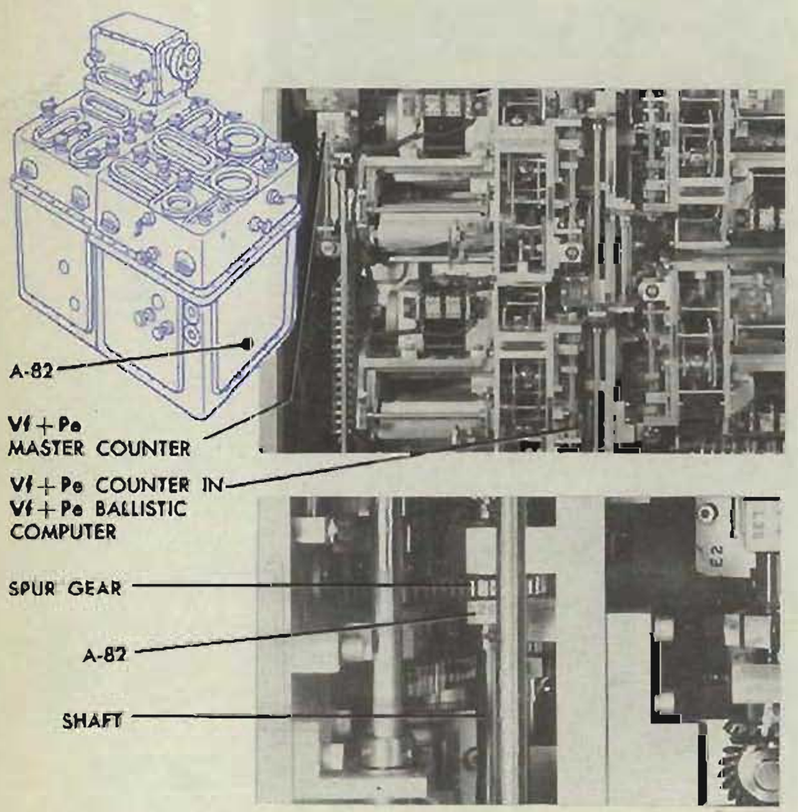
Loosen A-80.
Remove the wedge. Use the inner horizontal shaft below the *Vf* + *Pe* ballistic cam to turn *Tf* gently in a decreasing direction until the lead screw reaches its lower limit. Set the *Tf* counter at 99.05. On Mods 8 and 12, set *Tf* at 99.21. Make A-81 slip-tight. Turn the shaft to turn the lead screw in an increasing direction until the *Tf* counter reads 5 seconds (050), or 8 seconds (080) on Mods 8 and 12.



To refine the adjustment, move the input rack from limit to limit by turning the gear behind A-135. Note any output on the *R2* follow-up output gearing. Turn the *Tf* gearing to correct for *one half* this output. When the multiplier lead screw is at the zero position where full travel of the input rack produces no output, hold the shaft going to the lead screw and reset the *Tf* counter at 5 seconds, or 8 seconds on Mods 8 and 12. Tighten A-81 and recheck.
Reconnect leads A and AA.
Readjust A-135 and A-80.
Check A-104.



A-82 Vf+Pe BALLISTIC COMPUTER to Vf+Pe MASTER COUNTER



Location

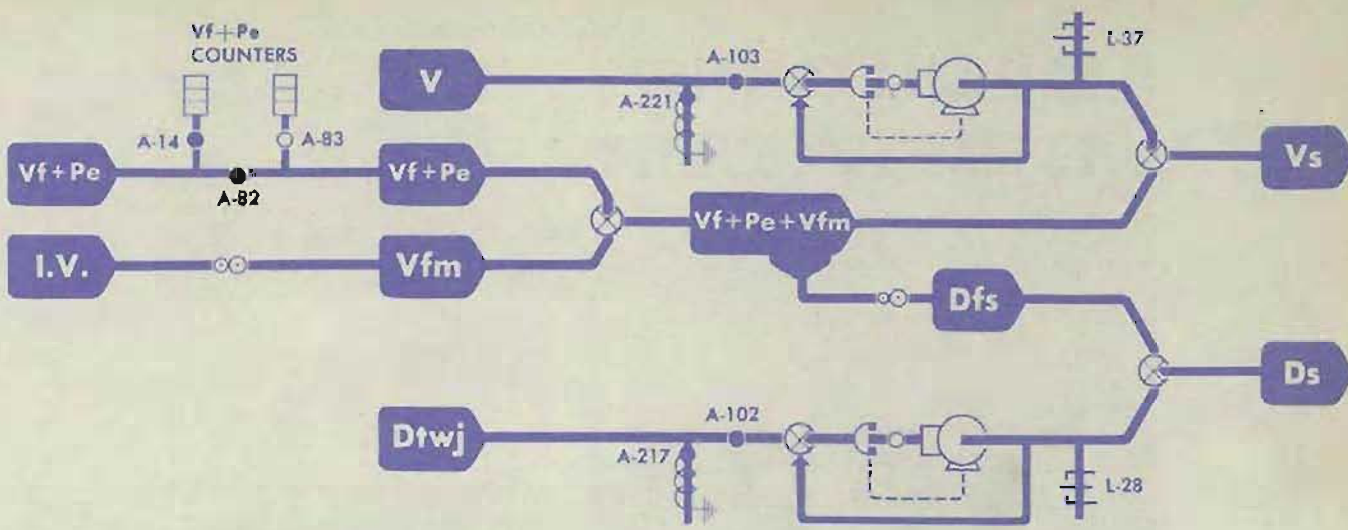
A-82 is under cover 4, to the right of the *Vf* + *Pe* ballistic computer.
Both *Vf* + *Pe* counters are under cover 4.

Check

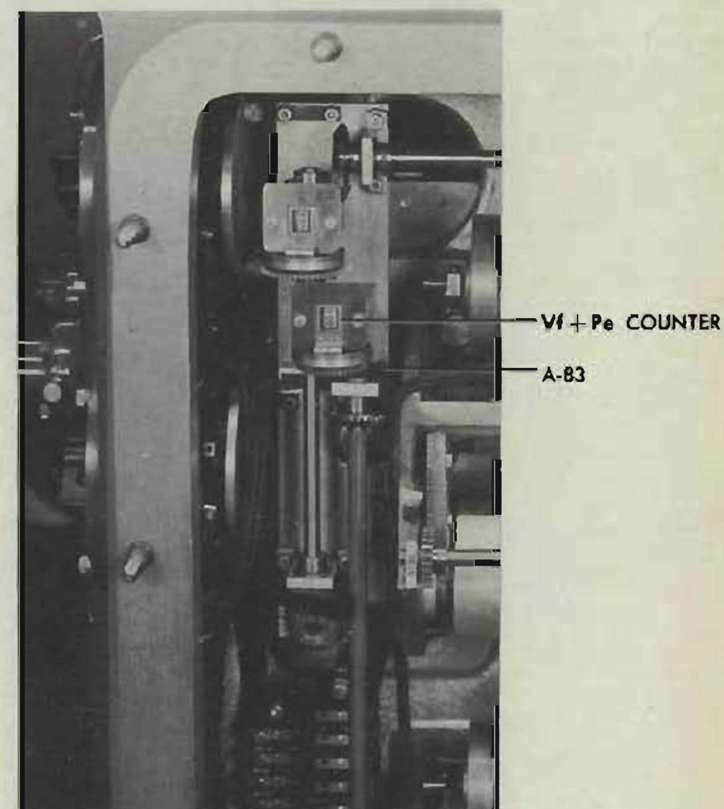
The *Vf* + *Pe* counters should agree.

Adjustment

If the counters do not agree, make A-82 slip-tight.
Hold the spur gear above the clamp and match the *Vf* + *Pe* master counter to the *Vf* + *Pe* ballistic computer counter by turning the shaft below A-82.
Tighten A-82 and recheck.
Check A-83, A-102, and A-103.



A-83 ASSEMBLY CLAMP



Location

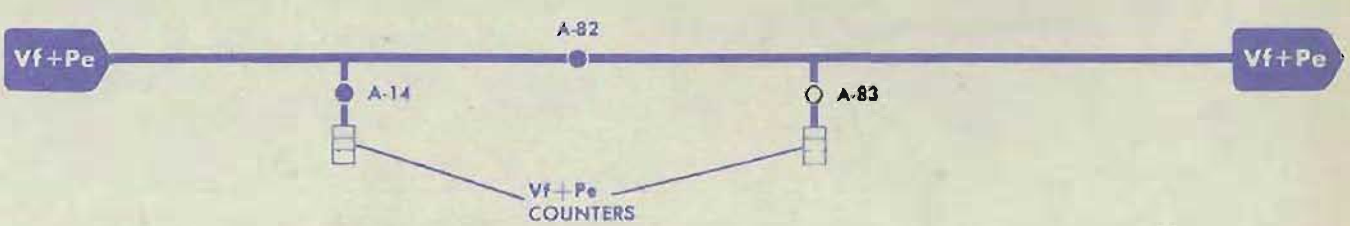
A-83 is under cover 4, below the *Vf* + *Pe* counter.

Check

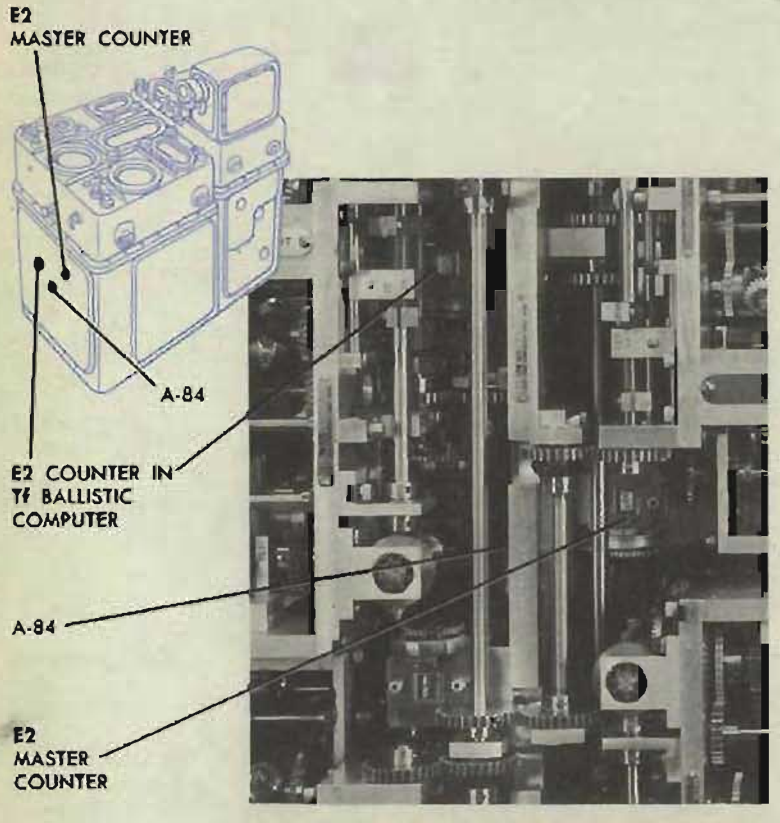
A-83 should be tight.

Adjustment

If A-83 is loose, tighten it.
Check A-82.



A-84 Tf BALLISTIC COMPUTER to E2 MASTER COUNTER



Location

A-84 is under cover 4, to the right of the *Tf* ballistic computer.

The *Tf* ballistic computer *E2* counter is located to the right of the *Tf* ballistic cam.

The *E2* master counter is under cover 4, in the center of the ballistic section above A-72.

Check

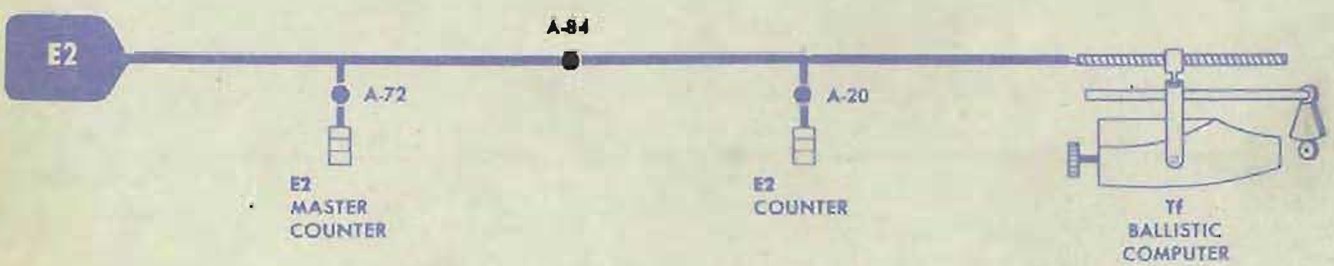
Both *E2* counters should agree.

Adjustment

If the counters do not agree, turn the power OFF. Make A-84 slip-tight.

Use a gear pusher to turn the spur gear above clamp A-84 until the *E2* counter in the *Tf* ballistic computer agrees with the *E2* master counter.

Tighten A-84 and recheck.



A-85 Vf + Pe BALLISTIC COMPUTER to E2 MASTER COUNTER

Location

A-85 is under cover 4, to the right of the *Vf* + *Pe* computer.

The *Vf* + *Pe* ballistic computer *E2* counter is above A-85.

The *E2* master counter is under cover 4, in the center of the ballistic section above A-72.

Check

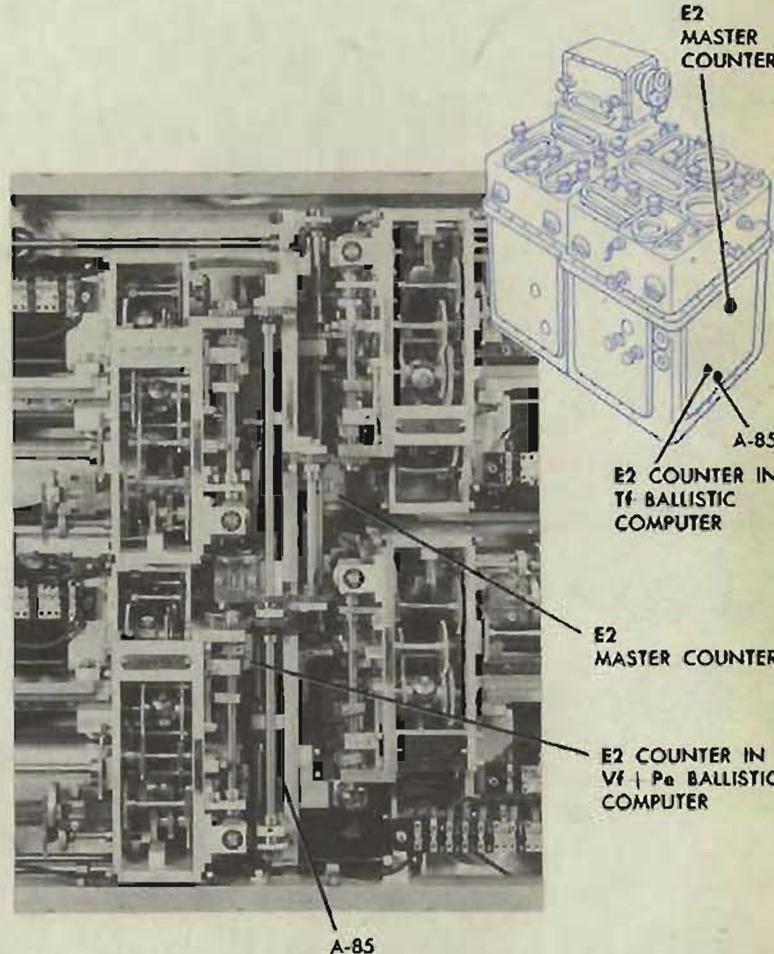
The *E2* counters should agree.

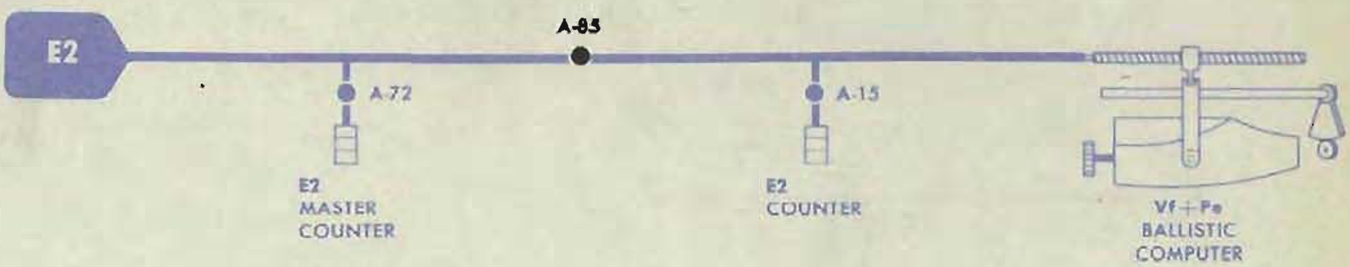
Adjustment

If the counters do not agree, make A-85 slip-tight.

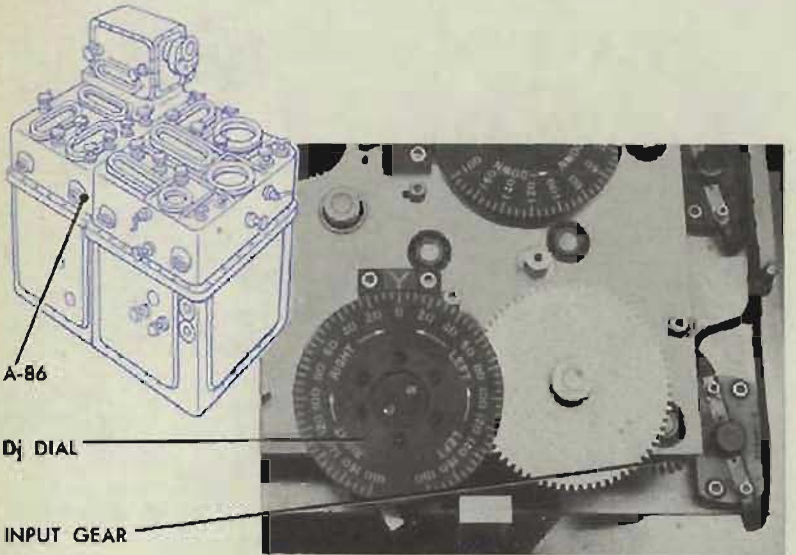
Turn the spur gear above the clamp, until the counters agree.

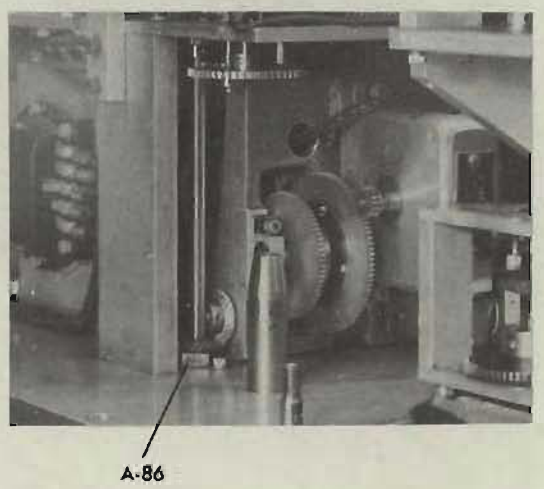
Tighten A-85 and recheck.





A-86 Dj DIAL to Dj RECEIVER





Location

A-86 is under cover 2.

Check

Turn the power ON.

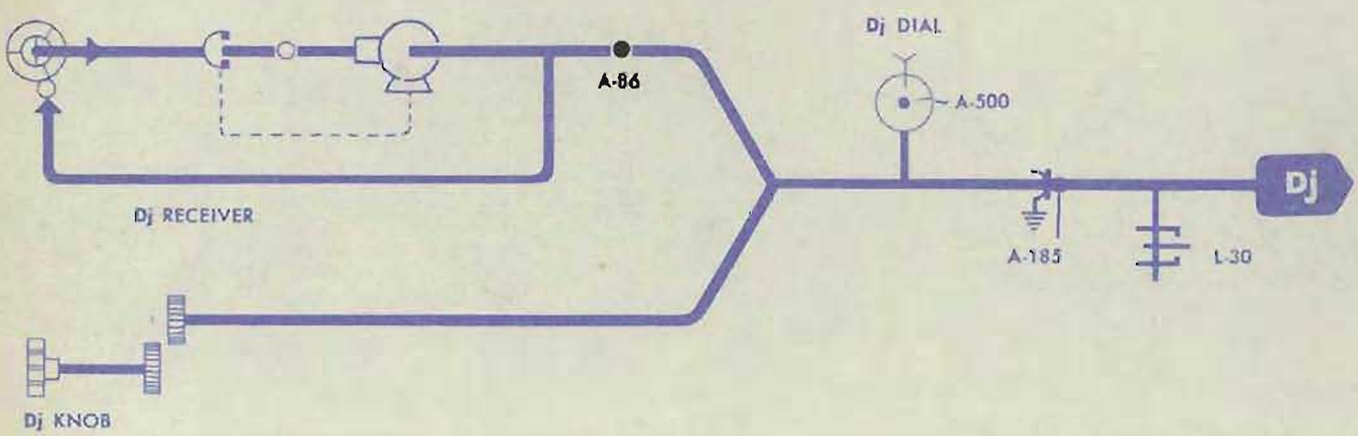
Pull the *Dj* knob OUT.
From the director, transmit 0 deflection spot.
The *Dj* follow-up will synchronize at its central position.
The *Dj* dial should read 0 mils.

Adjustment

If the *Dj* dial does not read 0, make A-86 slip-tight. Bring the *Dj* dial to 0 by turning the *Dj* input gear.

Tighten A-86, and recheck.

Check A-500.



A-87 Vj DIAL to Vj RECEIVER

Location

A-87 is under cover 2, near the main plate of the rear top section. It can be reached only from the rear.

Check

Turn the power ON.

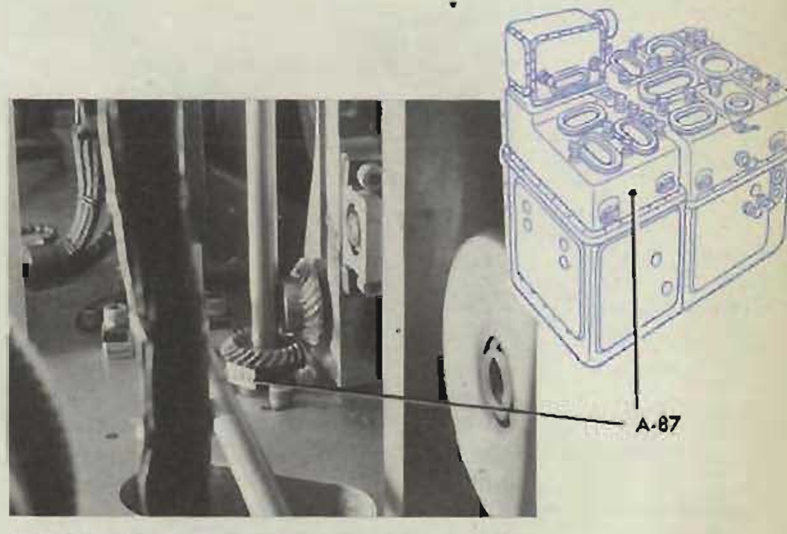
Pull the *Vj* knob OUT.
From the director, transmit 0 elevation spot.
The *Vj* dial should read 0 mils.

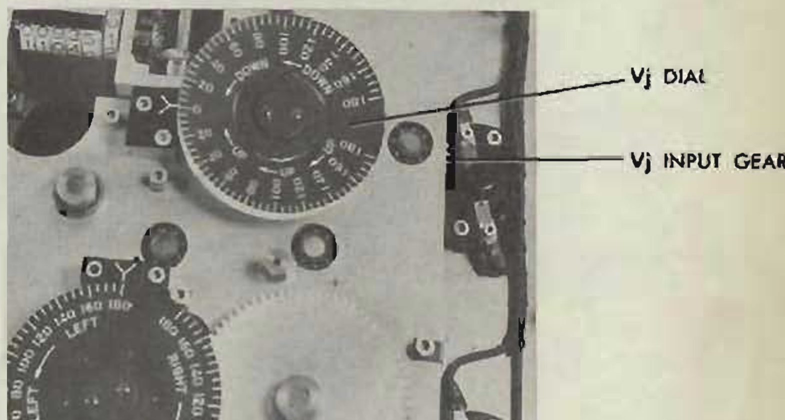
Adjustment

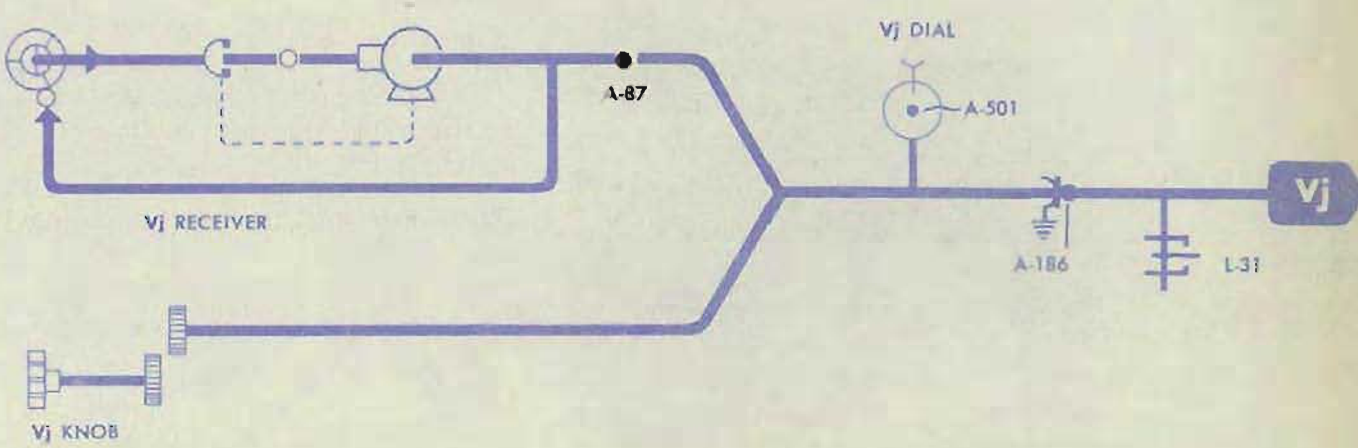
If the *Vj* dial does not read 0 mils, loosen A-87.
Bring the dial to 0 mils by turning the *Vj* input gear.

Tighten A-87 and recheck.

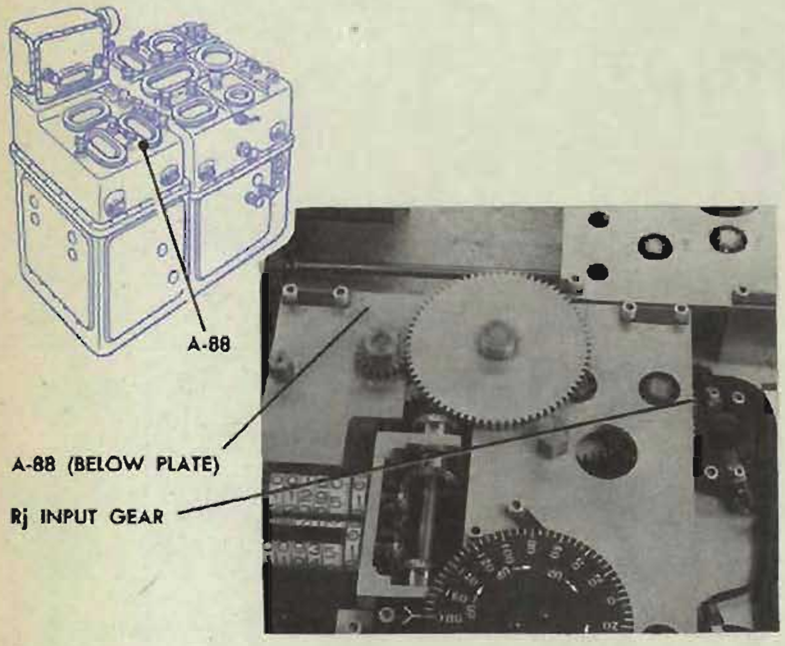
Check A-501.







A-88 Rj COUNTERS to Rj RECEIVER



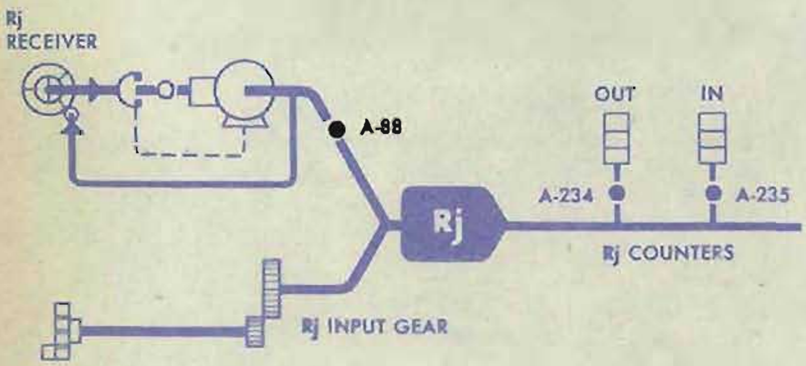
Location

A-88 is under cover 2, under the mounting plate to the right of the *Rj* counter, near the deck plate. It is reached from the left side of the instrument.

Check

Turn the power ON.

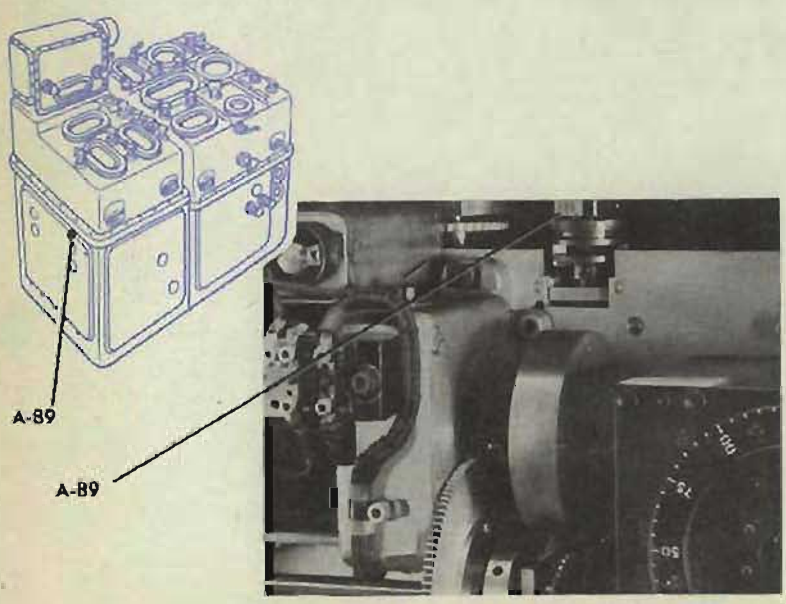
Pull the *Rj* handcrank OUT.
Transmit *Rj* from the director.
The computer *Rj* counters should agree with the director *Rj* dials.



Adjustment

If the *Rj* counters do not agree with the director *Rj* dials, make A-88 slip-tight. Make the counters agree with the director dials by turning the *Rj* input gear.
Tighten A-88 and recheck.
Check A-234, A-235.

A-89 Ds INDICATING to Ds MASTER COUNTER



Location

A-89 is under cover 7.

The *Ds* indicating counter is at the top of the indicating unit, next to the *Ds* handcrank.

The *Ds* master counter is under cover 8.

Check

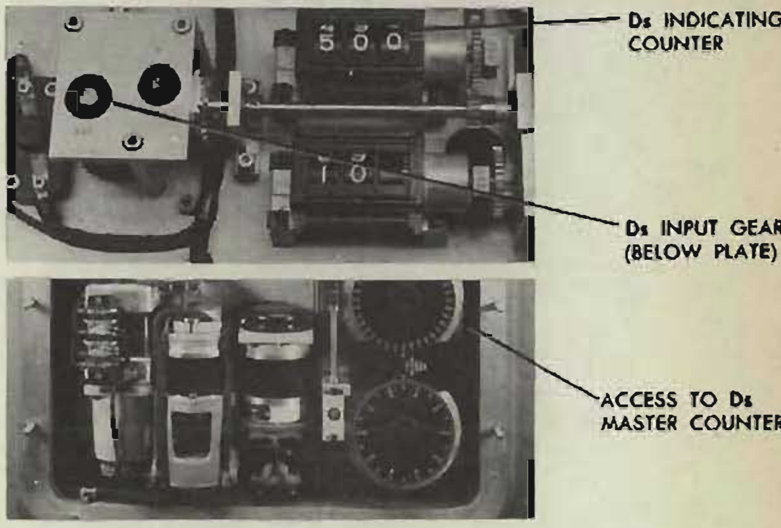
Both *Ds* counters should agree.

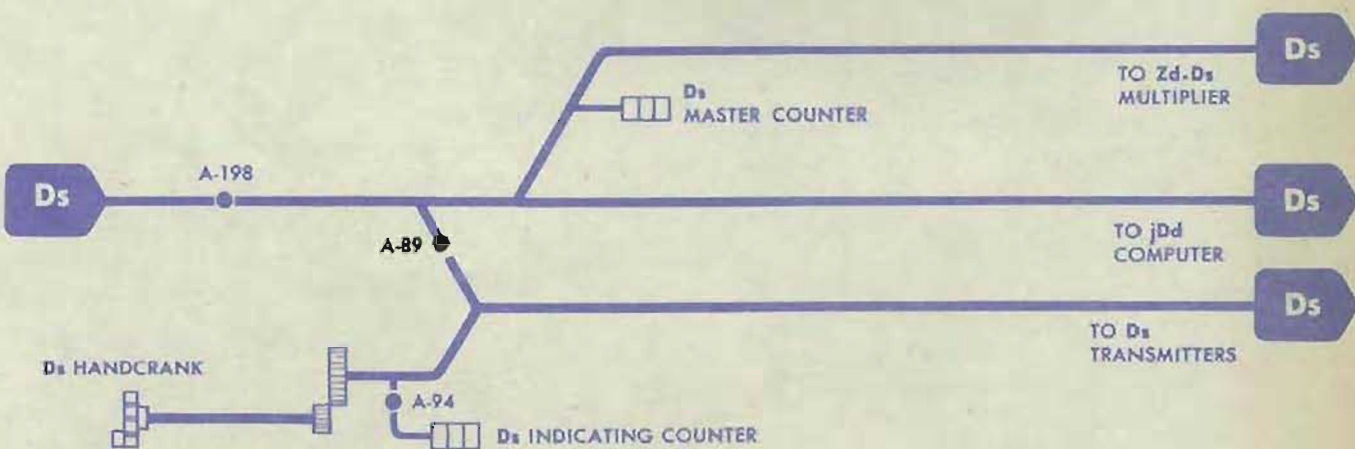
Adjustment

If the *Ds* counters do not agree, make A-89 slip-tight.
Turn the power OFF.
Wedge the output gearing of the *Dtwj* and *Vf* + *Pe* follow-ups.
Bring the *Ds* indicating counter to the same reading as the *Ds* master counter by turning the *Ds* input gear.
Tighten A-89 and recheck.

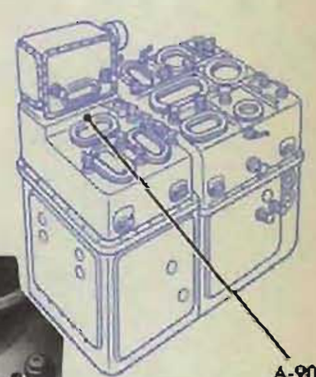
Remove the wedges from the *Dtwj* and *Vf* + *Pe* follow-up output gearing.

Check A-198 and A-94.





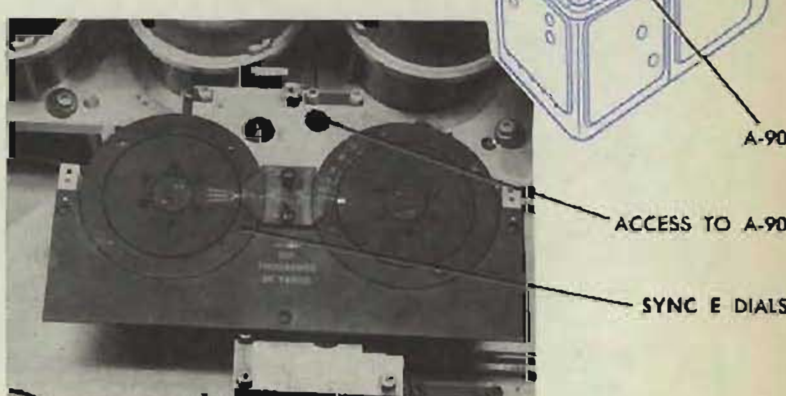
A-90 SYNC E DIALS to L-11

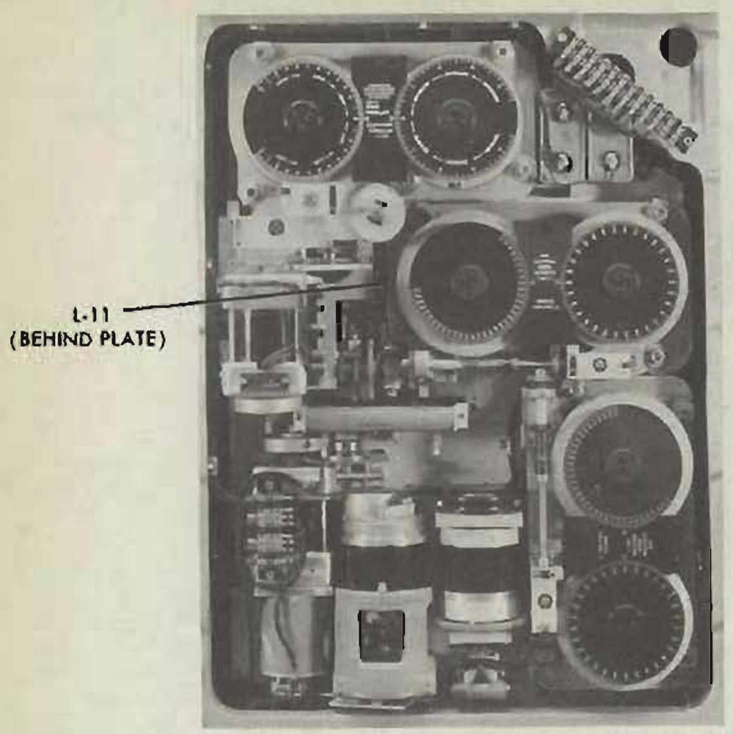


Location

A-90 is under cover 2, below the right half of the sync *E* dial mask. It can be reached through the small access hole, after the dial mask is removed.

L-11 is under cover 6, near the deck tilt multipliers.
The shaft is horizontal, and the lower limit is toward the left.





Check

Lower limit

Set *L* at 800′.
Set *E* at –5° with the sync *E* handcrank in the CENTER position. Then turn the handcrank counterclockwise in the OUT position until the limit of L-11 is reached.
The sync *E* dials should be matched at the fixed index.

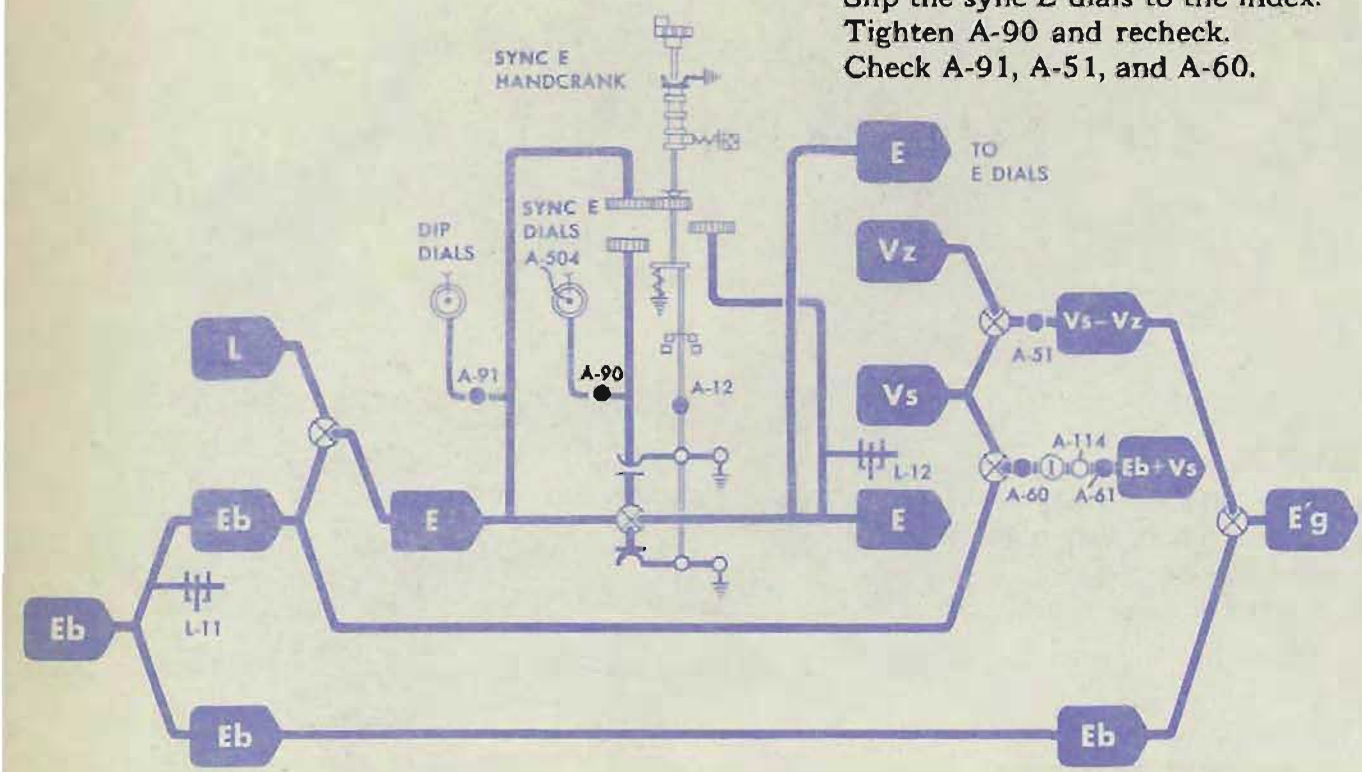
Upper limit

Set *L* at 3500′.
Set *E* at 85° with the sync *E* handcrank in the CENTER position. Then turn the handcrank clockwise in the OUT position until the limit of L-11 is reached. The sync *E* dials should be matched at the fixed index.

NOTE:
There may be a slight overtravel at each limit.

Adjustment

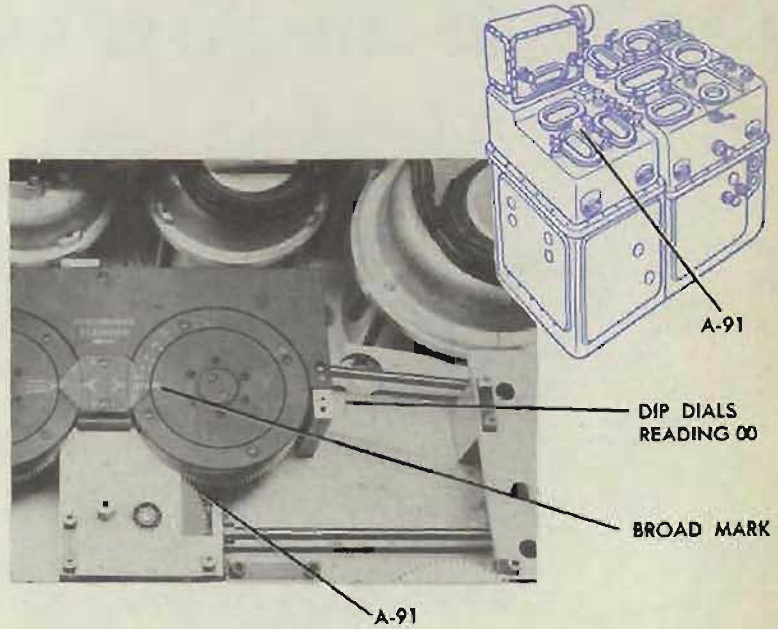
If the sync *E* dials do not match at the fixed index, at either limit of L-11, loosen A-90.
Slip the sync *E* dials to the index.
Tighten A-90 and recheck.
Check A-91, A-51, and A-60.



A-91 DIP DIALS to SYNC E LINE

Location

A-91 is under cover 2, below the left half of the sync *E* dial mask.



Check

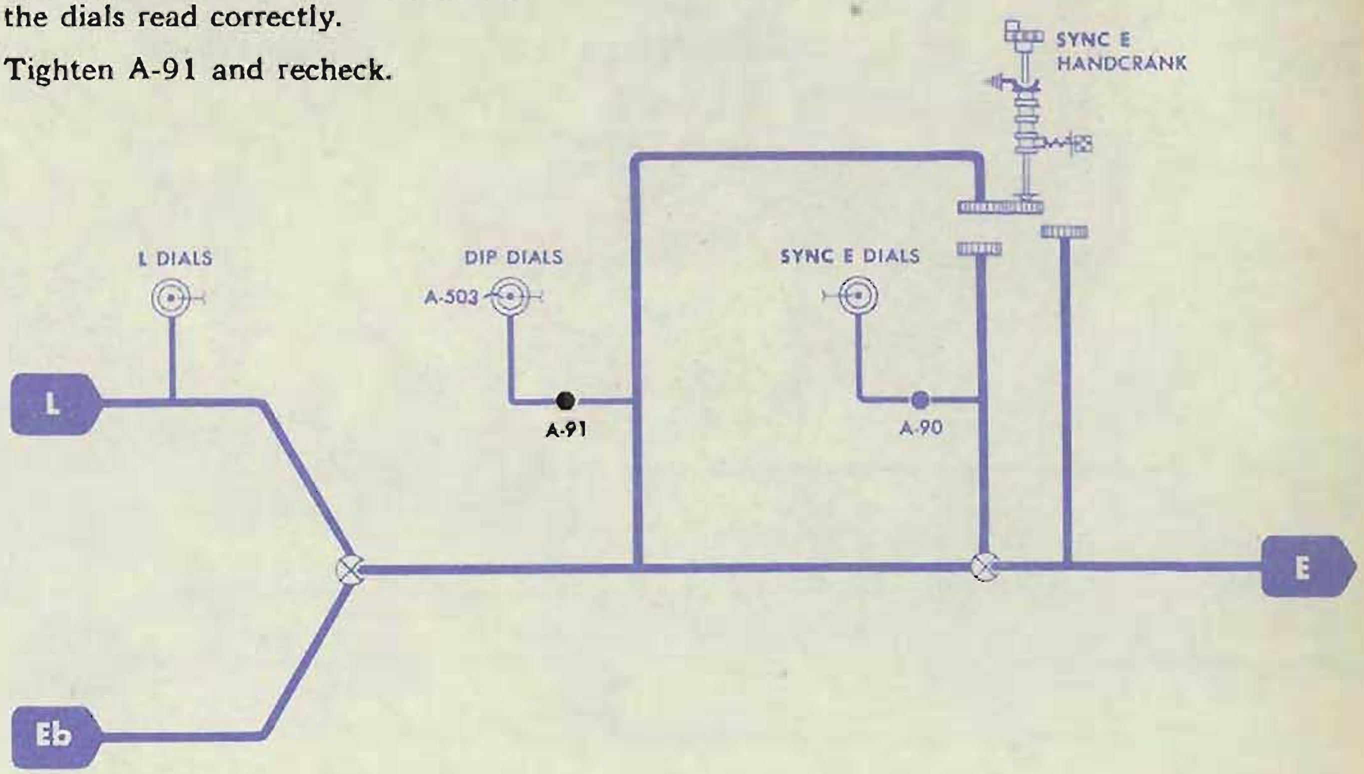
Set *L* at 2000′ on the computer *L* dials.
Set *E* at 0°, with the sync *E* handcrank at CENTER.
Match the sync *E* dials at the fixed index, with the sync *E* handcrank OUT.
The dip dials should now be positioned with the infinity mark and the counterclockwise edge of the broad index mark at the fixed index.

Adjustment

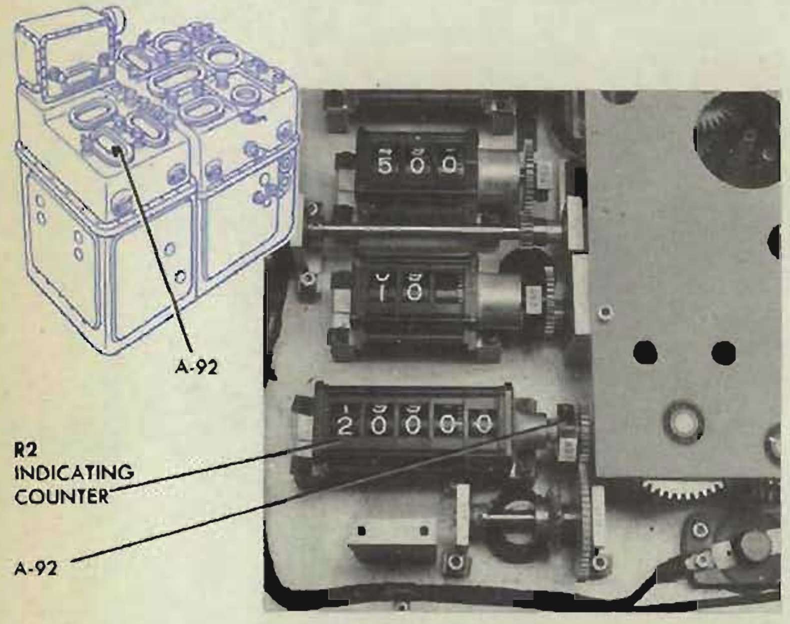
If the dip dials are not correctly positioned, slip-tighten A-91.

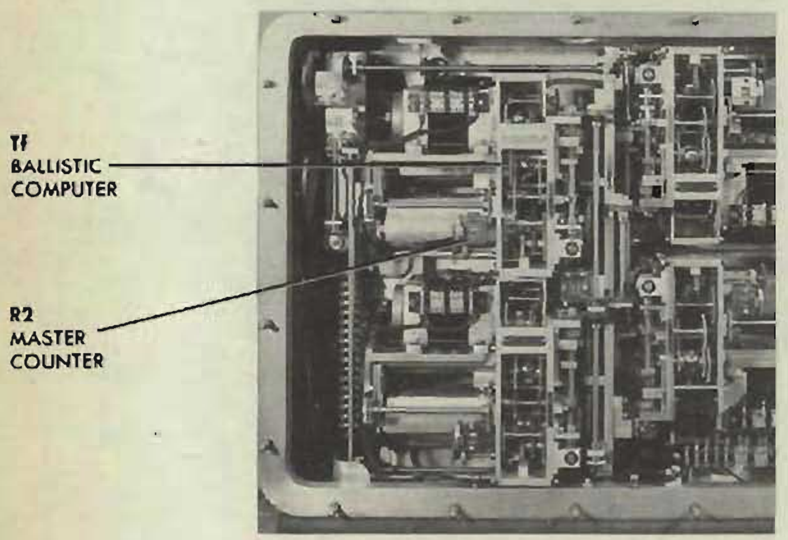
Use a gear pusher to turn the vertical bevel gear at the rear of A-91 until the dials read correctly.

Tighten A-91 and recheck.



A-92 R2 INDICATING to R2 MASTER COUNTER





Location

A-92 is on the *R2* indicating counter shaft. The *R2* master counter is under cover 4, in the *Tf* ballistic computer.

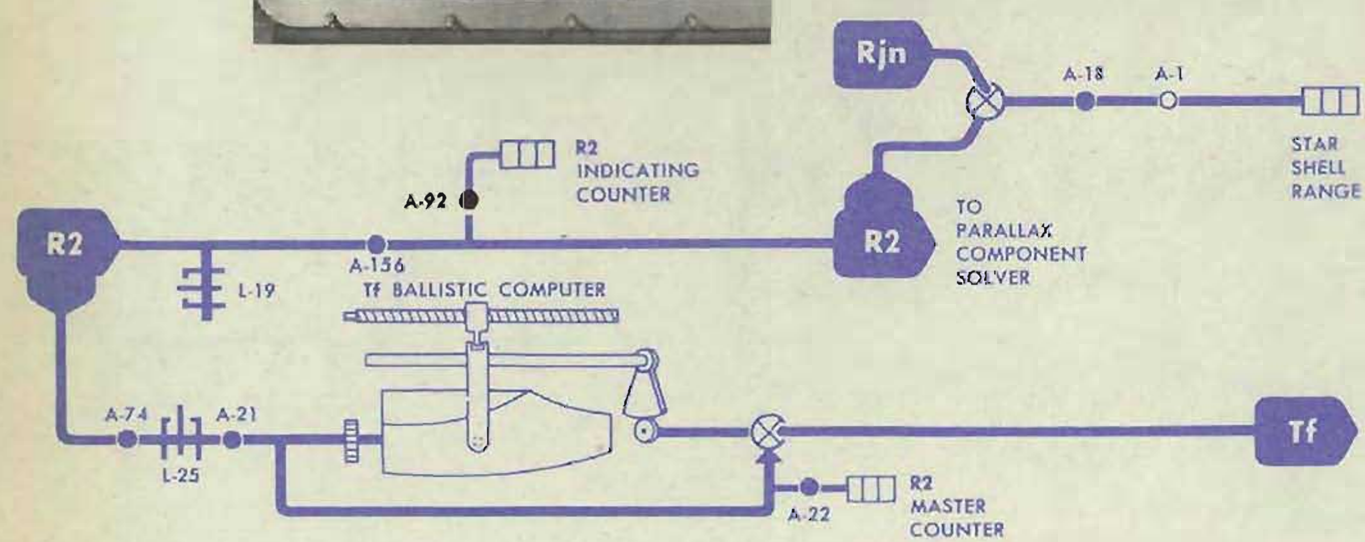
Check

The *R2* counter readings should agree.

Adjustment

If the *R2* indicating counter does not agree with the *R2* master counter, loosen A-92.
Turn the *R2* indicating counter until it agrees with the *R2* counter in the ballistic section.

Tighten A-92 and recheck.
Check A-18 in the star shell computer.



A-93 F INDICATING COUNTER to F TRANSMITTER

Location

A-93 is under cover 2 on the *F* counter shaft.

Check

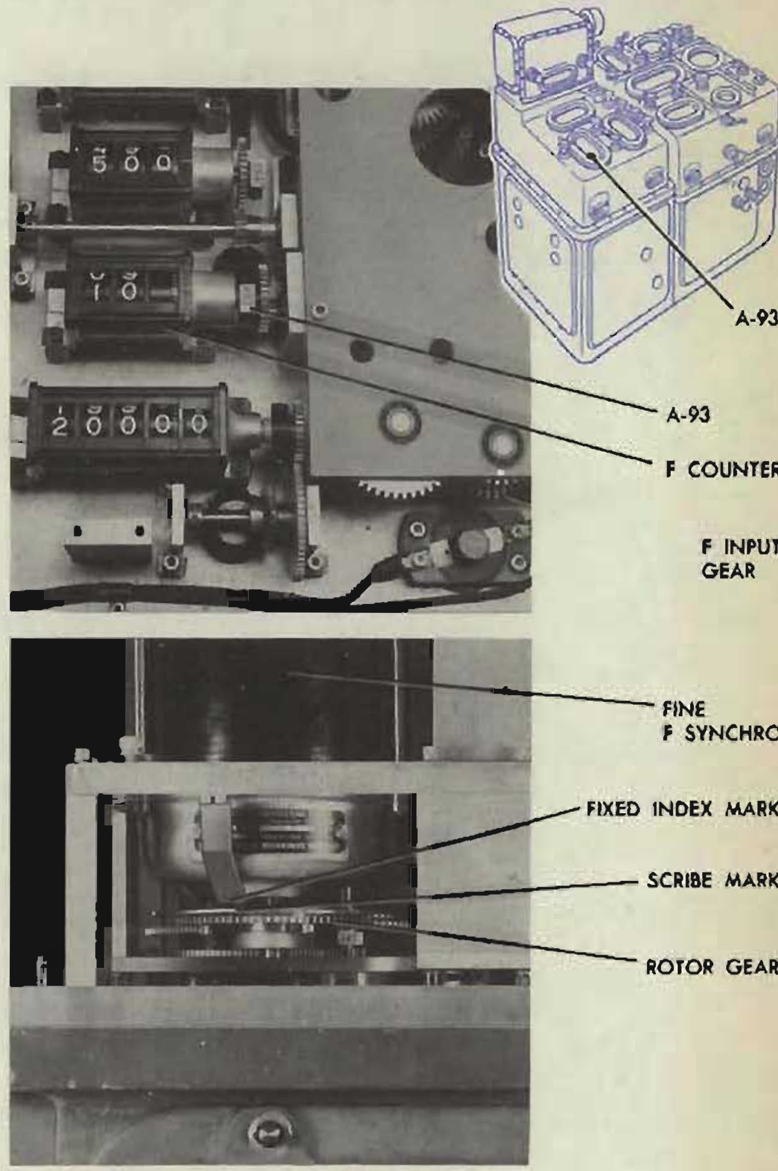
Set the *F* counter at 10 seconds. Use the *F* input gear.
The *F* transmitter should be on electrical zero.
Both synchros are on electrical zero when the scribe marks on the rotor gears match the fixed indexes.

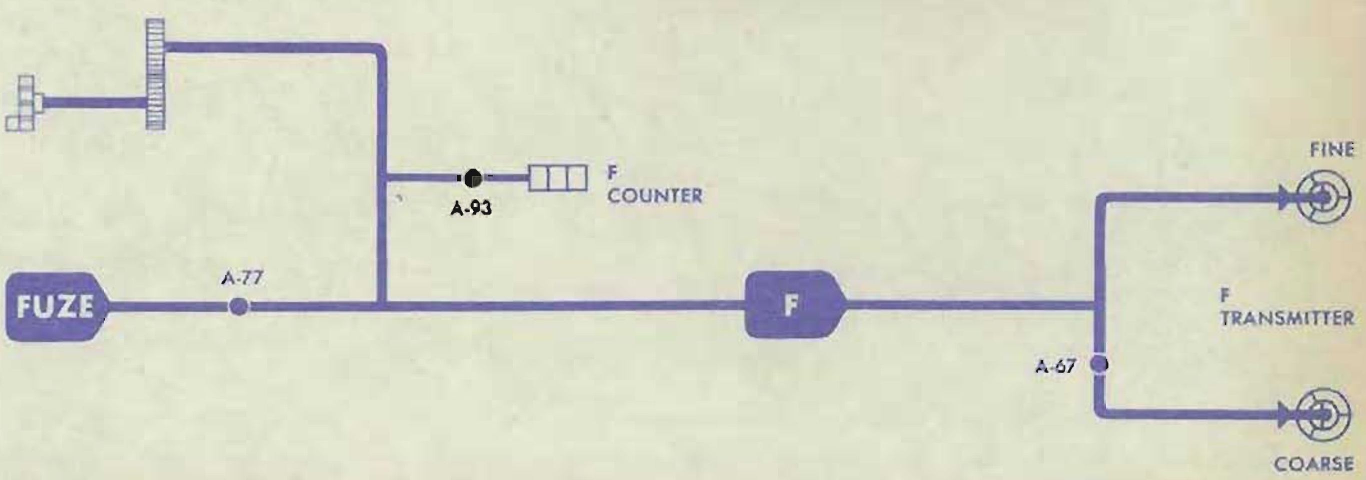
Adjustment

If the transmitter is not on electrical zero, make A-93 slip-tight.

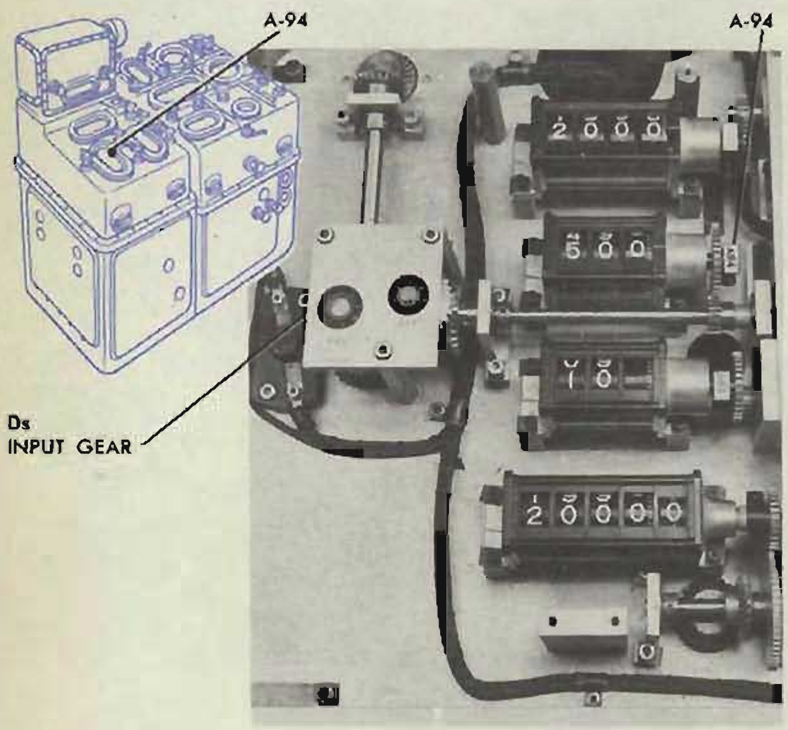
Hold the *F* counter at 10 seconds. Turn the *F* input gear until the transmitter is on electrical zero.

Tighten A-93 and recheck.
Readjust A-77 and check A-67.





A-94 Ds INDICATING COUNTER to Ds DOUBLE-SPEED TRANSMITTER



Location

A-94 is under cover 2, on the *Ds* indicating counter shaft.

Check

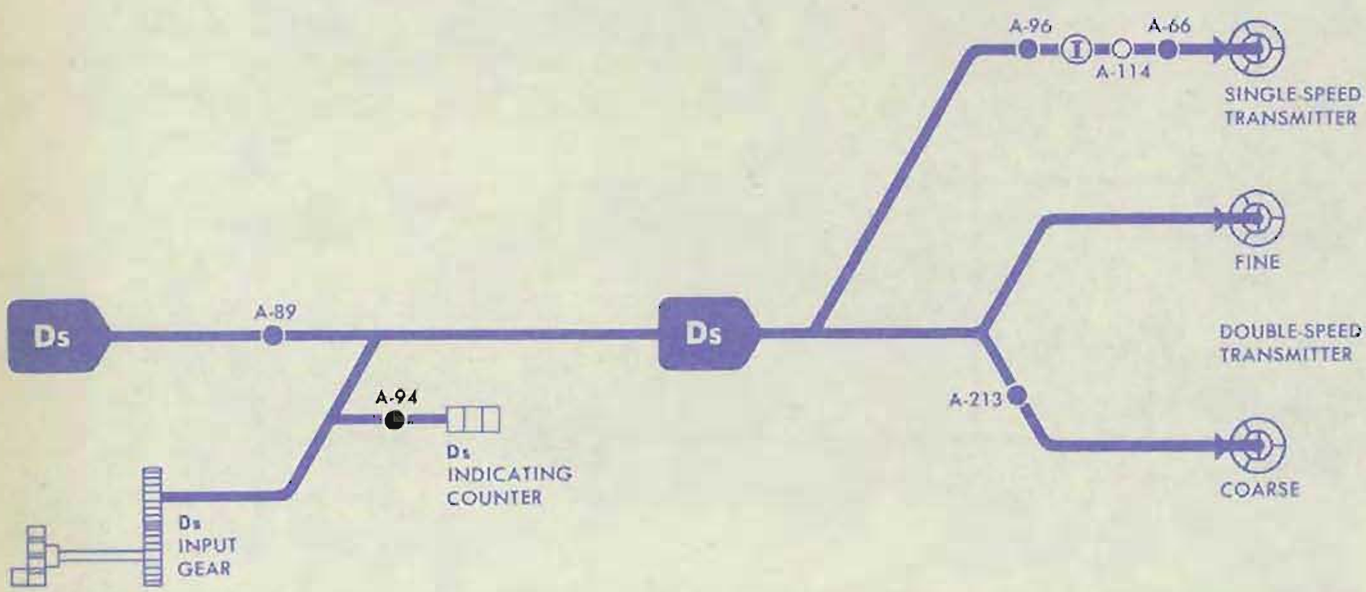
On Mods 0, 2, and 6, A-94 is an assembly clamp. Check that it is tight.

On other mods, proceed as follows: Set the *Ds* counter at 500 mils. The *Ds* double-speed transmitter should be on electrical zero. Both synchros are on electrical zero when the scribe marks on the rotors match the fixed indexes.

Adjustment

If both synchros are not on electrical zero, make A-94 slip-tight. Hold the counter at 500 mils and bring the synchros to electrical zero by turning the *Ds* input gear.

Tighten A-94 and recheck.
Readjust A-89 and check A-96.



A-95 Vs INDICATING COUNTER to Vs DOUBLE-SPEED TRANSMITTER

Location

A-95 is under cover 2, on the *Vs* counter shaft.

Check

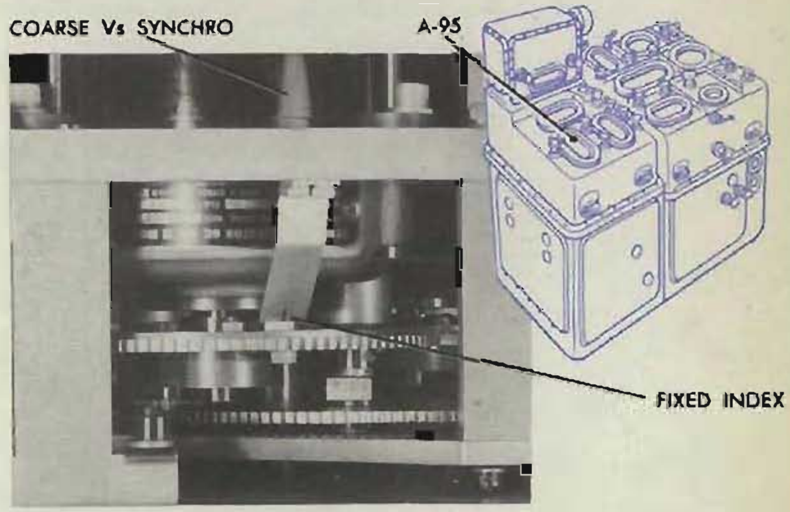
On Mods 0, 2, and 6, A-95 is an assembly clamp. Check that it is tight.

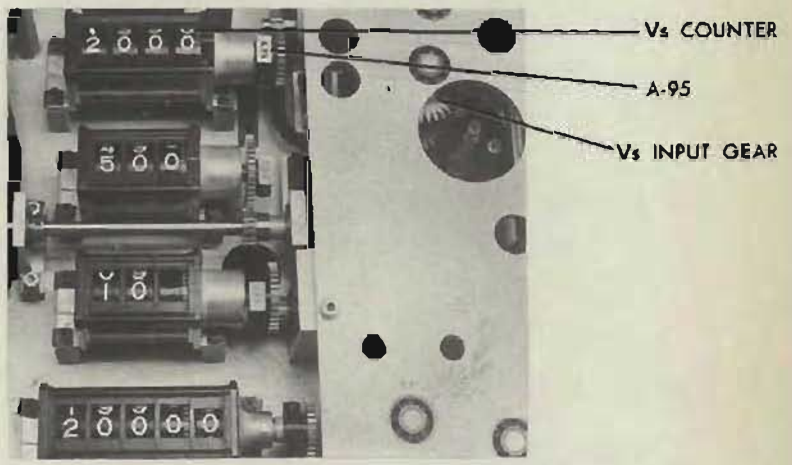
On other mods, proceed as follows: Set the *Vs* counter at 2000′. Use the *Vs* input gear. The *Vs* double-speed transmitter should now be on electrical zero. Both synchros are on electrical zero when the scribe marks on the rotors match the fixed indexes.

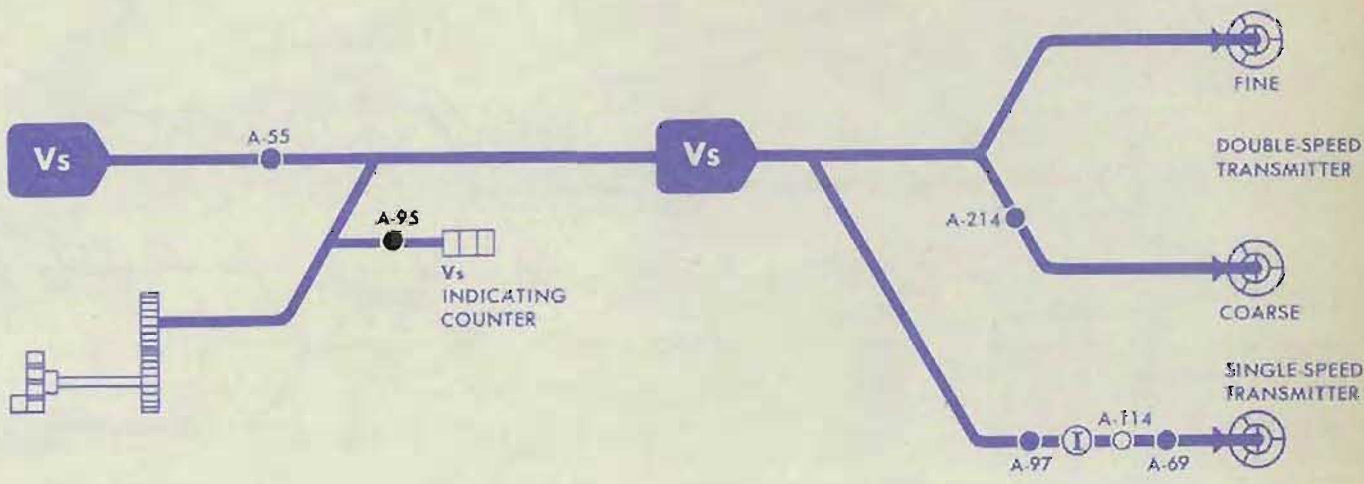
Adjustment

If both synchros are not on electrical zero, make A-95 slip-tight. Hold the counter at 2000′ and bring the synchros to electrical zero by turning the *Vs* input gear.

Tighten A-95 and recheck.
Readjust A-55 and check A-97.







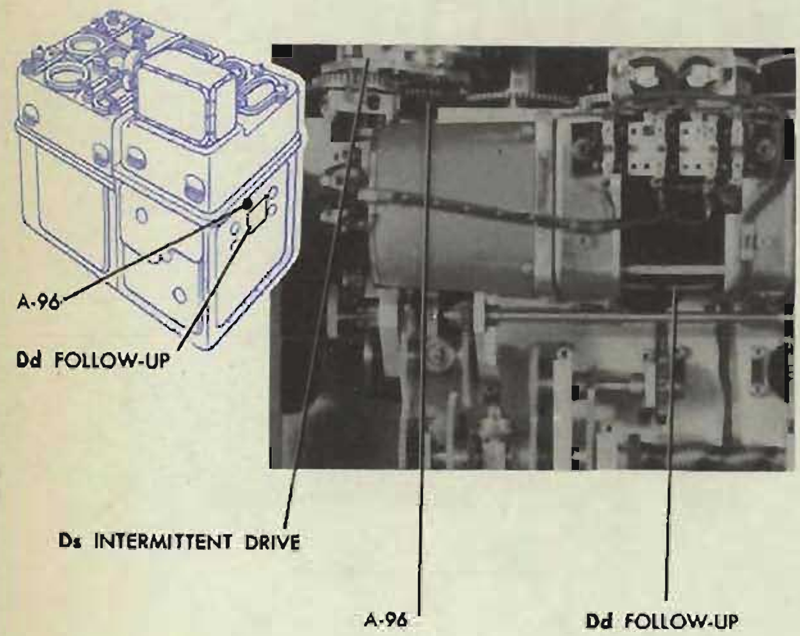
CONTENTS

Enter the page number you want into your reader's page locator.

VOLUME ONE

VOLUME TWO

A-96 Ds INTERMITTENT DRIVE to Ds INDICATING COUNTER



Location

A-96 is under cover 7, on the input to the *Ds* intermittent drive. A-96 is omitted on Mods 1, 3, 4, 8, and 12.

Check

Decrease *Ds* and observe the output gear of the intermittent drive. It should stop turning when the *Ds* counter reaches 320 mils. The intermittent drive is then at its low cut-out point.

Adjustment

If the intermittent drive does not cut out when *Ds* reads 320 mils, make A-96 slip-tight.

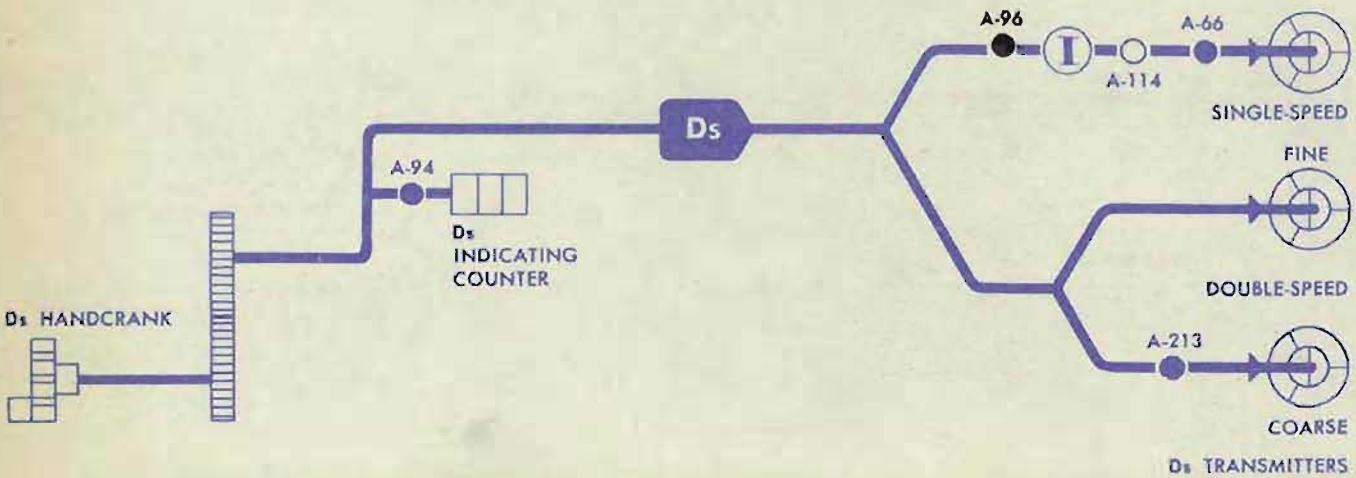
Turn *Ds* in a decreasing direction until the output gear stops turning. Hold the large gear in the intermittent drive and turn the *Ds* handcrank to set the counter at 320.

Tighten A-96.

Recheck

Increase *Ds* until the intermittent drive output gear stops turning. The *Ds* counter should read 680 mils at the upper cutout point of the intermittent drive.

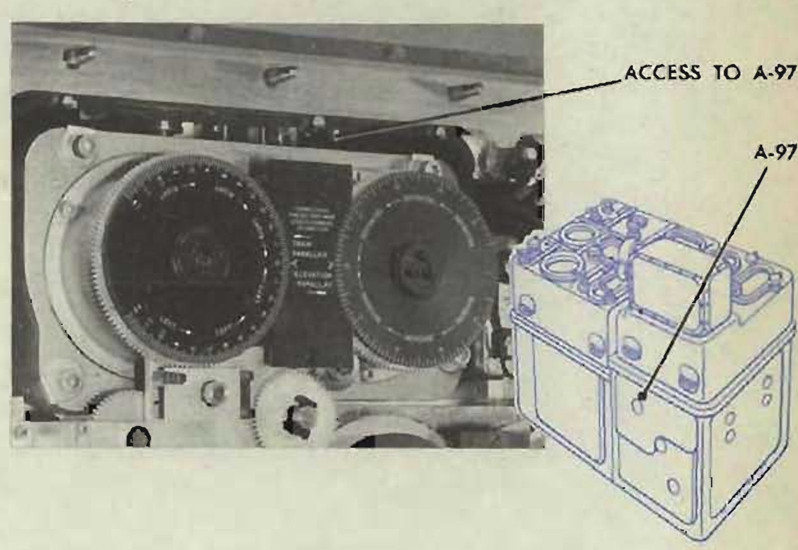
Check A-66.



A-97 Vs INTERMITTENT DRIVE to Vs INDICATING COUNTER

Location

A-97 is under cover 6, 14 inches in from the access space at the top of the *Pv* transmitter. It is on the input shaft of the *Vs* intermittent drive. A-97 is omitted on Mods 1, 3, 4, 8, and 12.



Check

Turn the *Vs* handcrank in a decreasing direction.

Observe the output gear of the intermittent drive. It should stop turning when the *Vs* counter reads 2000′. The intermittent drive is then at its low cut-out point.

Adjustment

If the intermittent drive does not cut out when *Vs* reads 2000′, make A-97 slip-tight.

Turn *Vs* in a decreasing direction until the drive does cut out. Hold the large gear in the intermittent drive by means of a gear pusher inserted through the access above the *Dd* follow-up under cover 7.

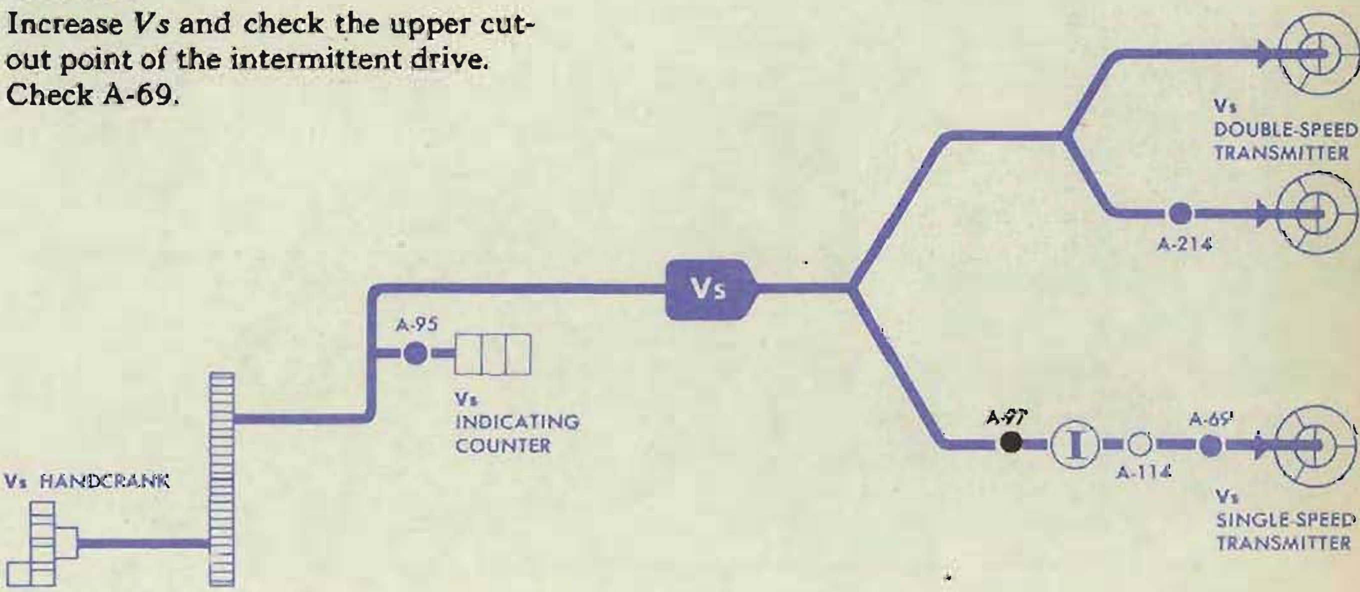
Bring the *Vs* counter to 2000′ with the *Vs* handcrank.

Tighten A-97.

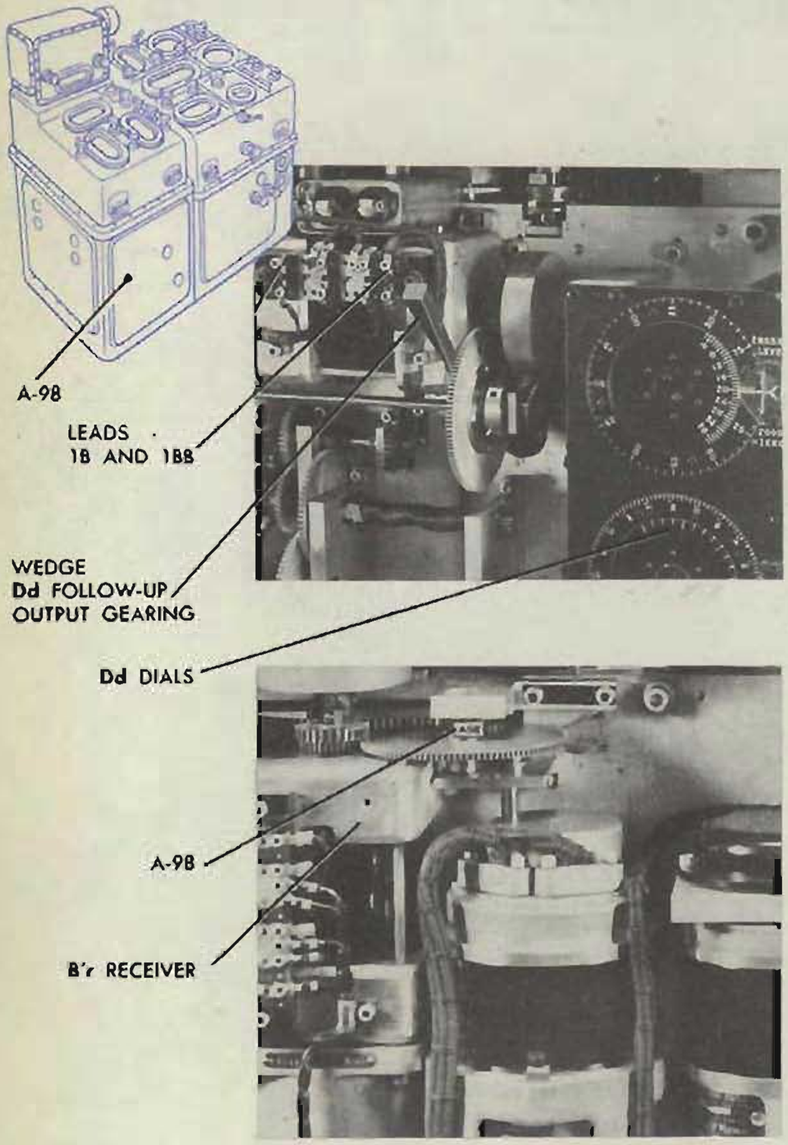
Recheck

Increase *Vs* and check the upper cut-out point of the intermittent drive.

Check A-69.



A-98 B'gr DIALS to B'r RECEIVER



Location

A-98 is under cover 8 on the response gearing of the *B'r* receiver.

Check

Remove leads 1B and 1BB from the *Dd* follow-up. Set *Dd* at 0° and wedge the output gearing.

Turn the power ON.

Turn the control switch to SEMI-AUTO.

Transmit *B'r* from the director. Read the value on the *B'gr* dials. *B'gr* should match the value of *B'r* being transmitted from the director.

Adjustment

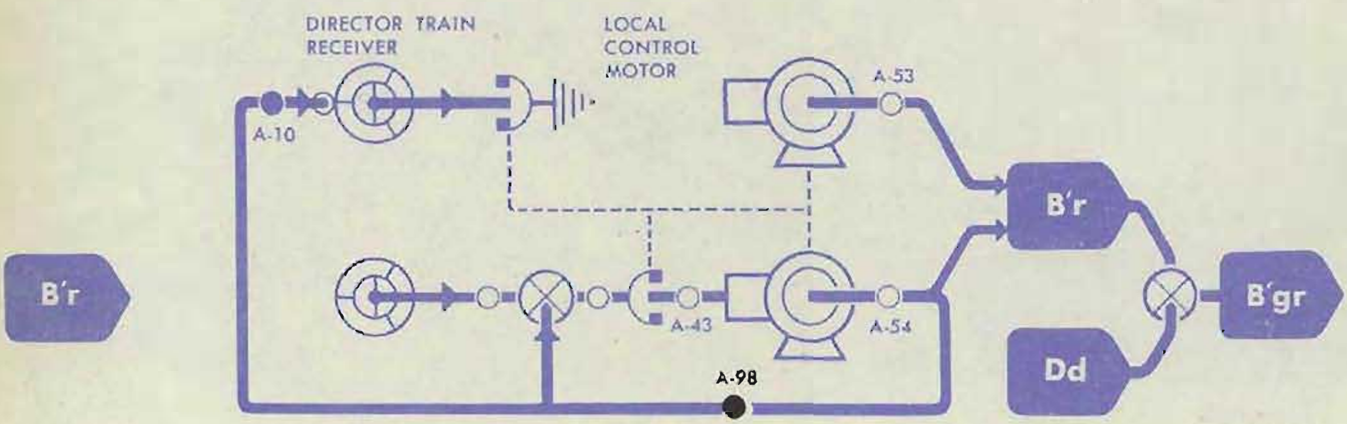
Make A-98 slip-tight.

Turn the gear directly beneath the gear on which clamp A-98 is mounted until the *B'gr* dials match the value transmitted from the director.

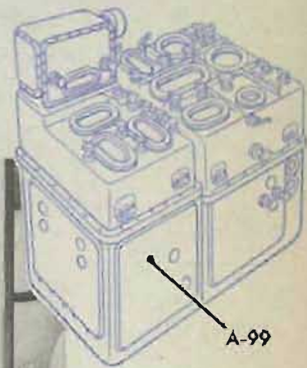
Tighten A-98 and recheck.

Caution

If A-98 is completely loosened, the receiver motor may run away.

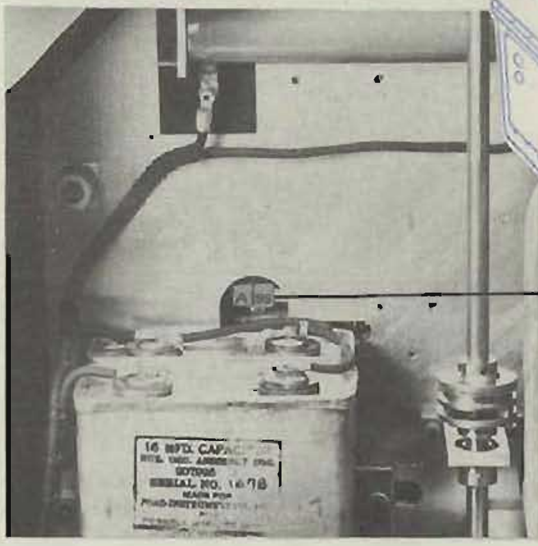


A-99 DECK TILT COMPONENT SOLVER to B'r LINE



Location

A-99 is under cover 8 above the two 16-mfd. capacitors.
The deck tilt component solver is under cover 7. It is visible through the access below the Vz follow-up.

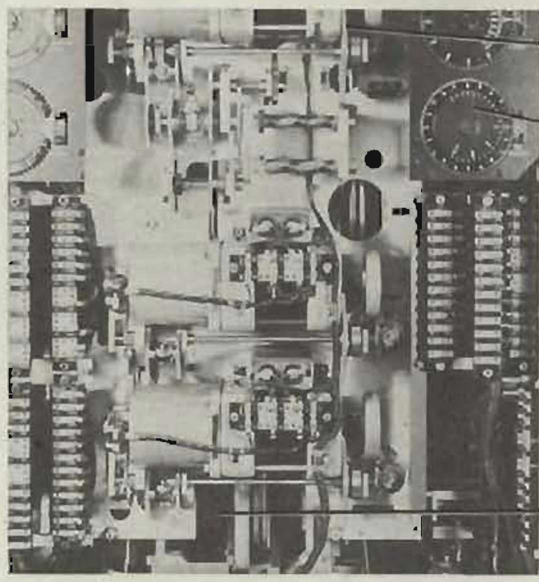


Check

Turn the power OFF.

Set Dd at 0° and wedge the follow-up output gear.
Set $B'gr$ at 45° and wedge the line.

Increase L and observe the motion of the L sin $2B'r$ rack of the deck tilt component solver. This is the rack which slides horizontally. It should move toward the rear of the computer as L is increased. If it does not, make both the coarse and fine adjustment given below.



If the direction of travel of the L sin $2B'r$ rack is correct, set up a dial indicator to measure motion of the L cos $2B'r$ rack (vertical slide). Turn L from limit to limit while observing the dial indicator. There should be no motion of the L cos $2B'r$ rack for the entire travel of L. If the rack motion is greater than 0.002 inch, make the fine adjustment given below.

Coarse adjustment

Set L at 3200'.

Loosen A-99, and turn the gear below the clamp until the L sin $2B'r$ rack is nearest the rear of the instrument. Make A-99 slip-tight.

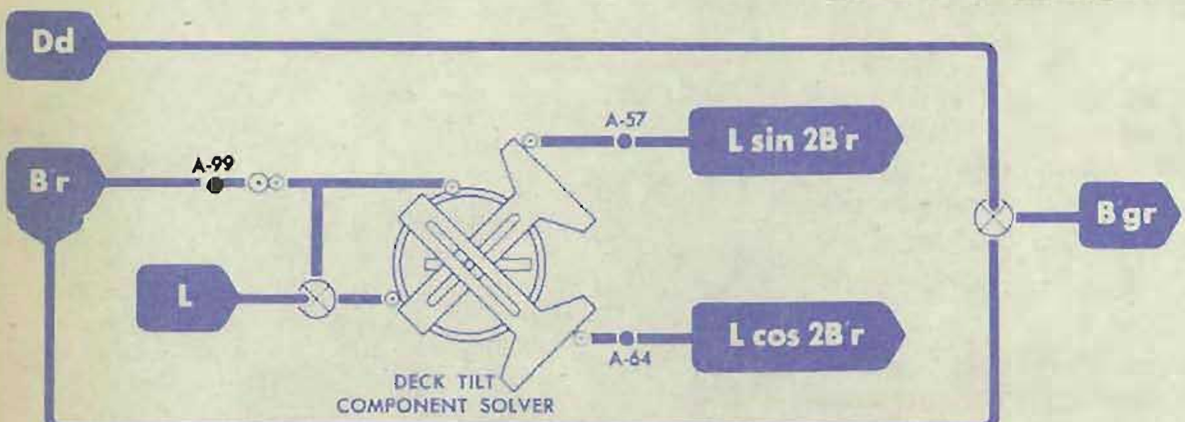
Fine adjustment

Check that *Dd* is at 0° and *B'gr* is at 45°. Set *L* at 2000'.

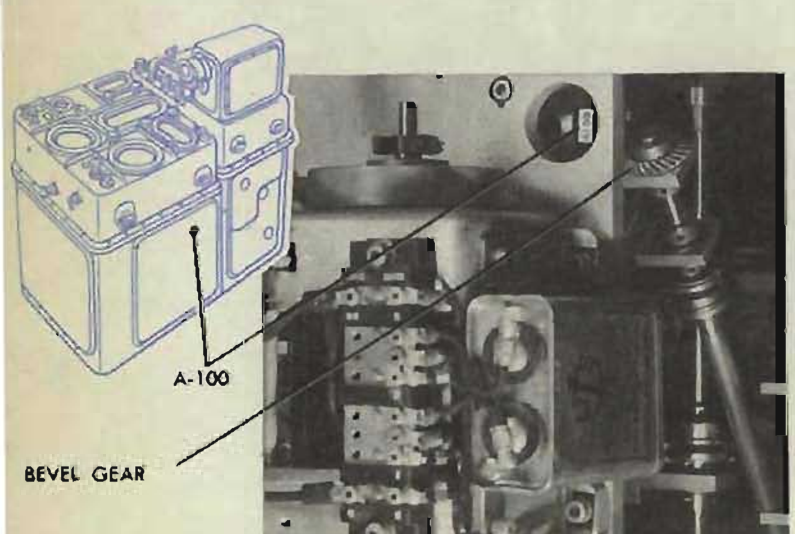
Set up a dial indicator to measure motion of the *L* cos *2B'r* rack (vertical slide), and observe the reading of the indicator. Increase *L* slowly, and turn the gear below A-99 to keep the indicator at its original reading. Continue until *L* has reached its upper limit of travel.

Tighten A-99, and recheck by turning *L* from its lower limit to its upper limit. There should be no motion of the dial indicator (limit 0.002 inch). Remove the dial indicator and all wedges.

Check A-57 and A-64.



A-100 ELEVATION WIND COMPONENT SOLVER to Ywgr LINE

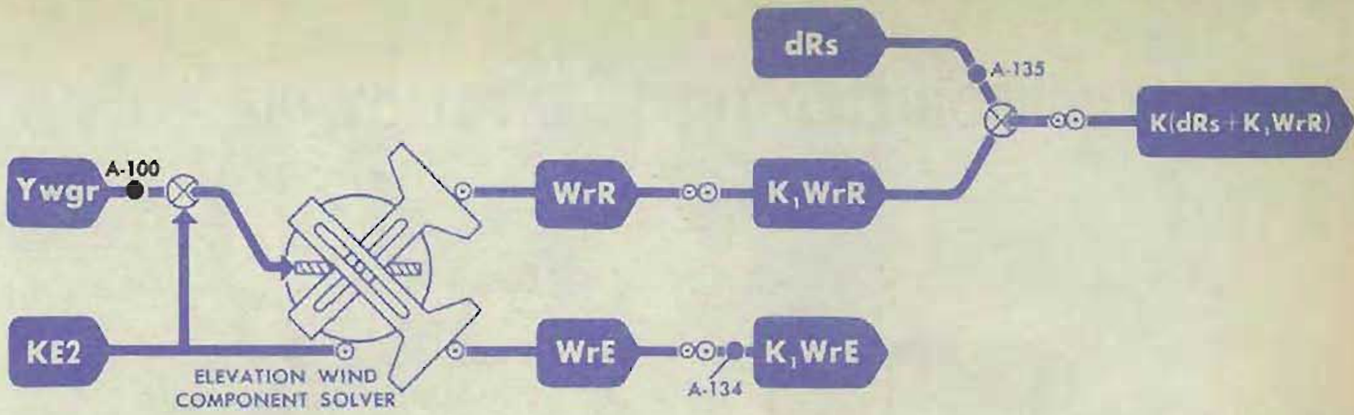


Location

A-100 is under cover 5. It is visible through the small access hole above the *Dtwj* follow-up.

Check

Set *Br* at 90°.
Set *Bws* at 90°.
Set *So* and *Sw* at 0 knots.
Set *Ds* at 500 mils.



Turn the power ON.

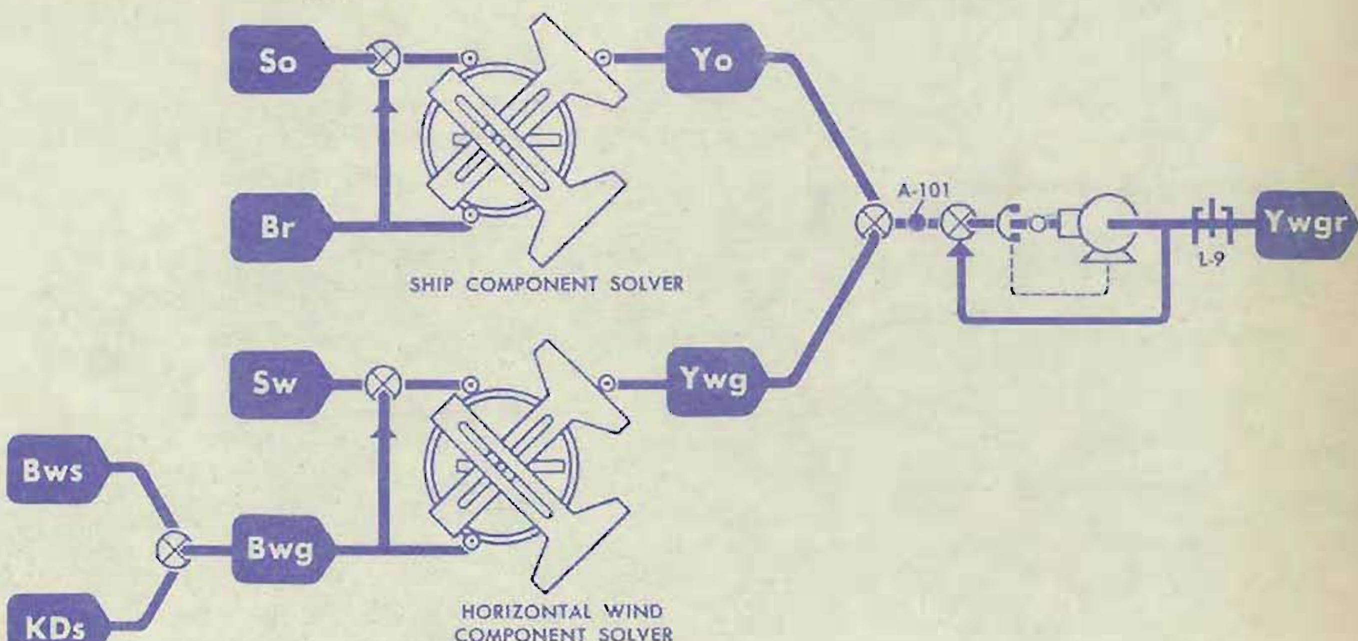
The input screw of the elevation wind component solver should be in such a position that rotation of the *E2* line produces no movement of the output racks.
Turn the *E2* line from 0° to 80°.
The *WrR* output rack can be seen under cover 3.

Adjustment

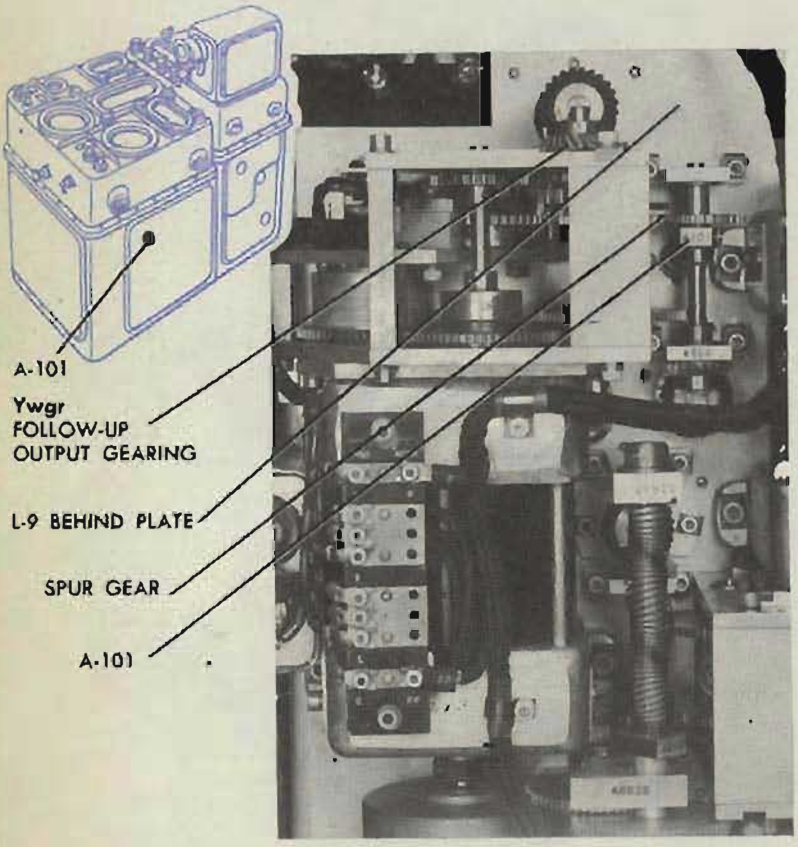
If there is any motion of the *WrR* output rack, make A-100 slip-tight.

Set *E2* at 78.95° and mark the position of the *WrR* rack.
Turn *E2* to 0°.
Turn the bevel gear near A-100 until the *WrR* rack is at its original position.

Tighten A-100 and recheck.
Check A-135 and A-134.



A-101 SYNCHRONIZING THE Ywgr FOLLOW-UP



Location

A-101 is under cover 5.

L-9 is behind the top of the follow-up mounting plate. It is in a horizontal position with its lower limit toward the front.

Check

Turn the power ON.

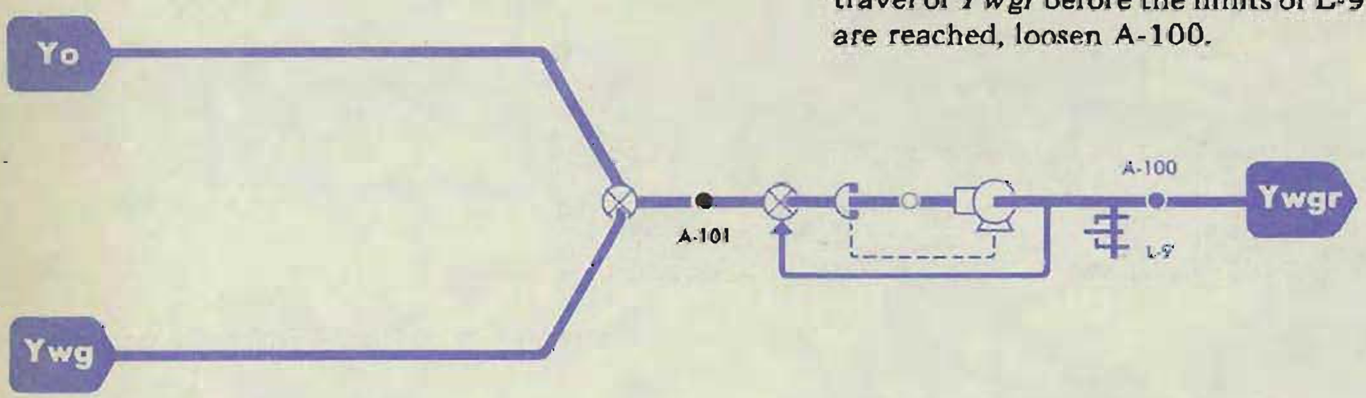
Set *Ds* at 500 mils.
Set *So* at 40 knots, and *Sw* at 60 knots.
Set *Co*, *Bw*, and *Br* at 0°.

The *Ywgr* follow-up should be synchronized at the lower limit, −100 knots.

CAUTION

Before making this adjustment, turn the power OFF and run *Ywgr* from one limit to the other by turning the *Ywgr* follow-up output gearing.

If there is any interference in the travel of *Ywgr* before the limits of L-9 are reached, loosen A-100.



Adjustment

If the follow-up is not synchronized at the lower limit, make A-101 slip-tight.

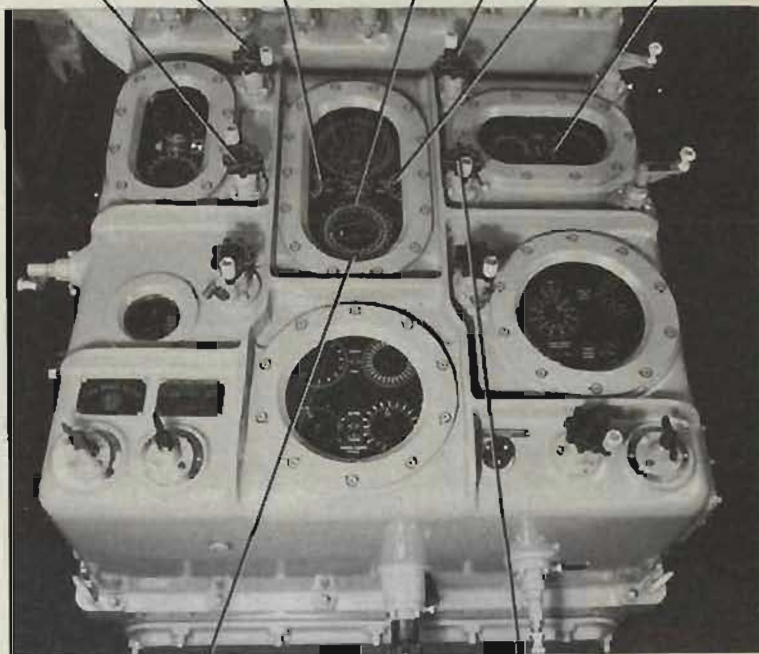
Turn the small spur gear above the clamp until the follow-up is synchronized at the lower limit.

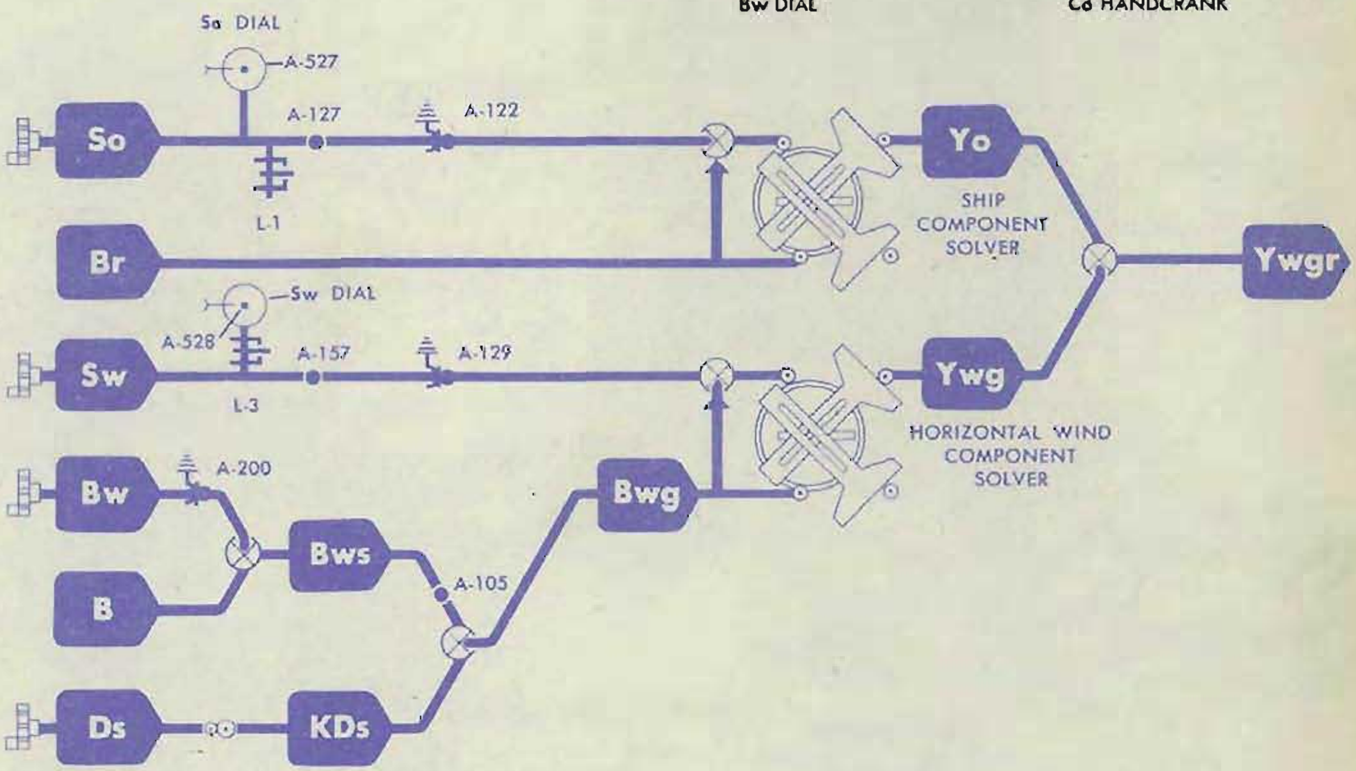
Change *Br* to 180°. The *Ywgr* follow-up should synchronize at the upper limit.

Tighten A-101 and recheck.

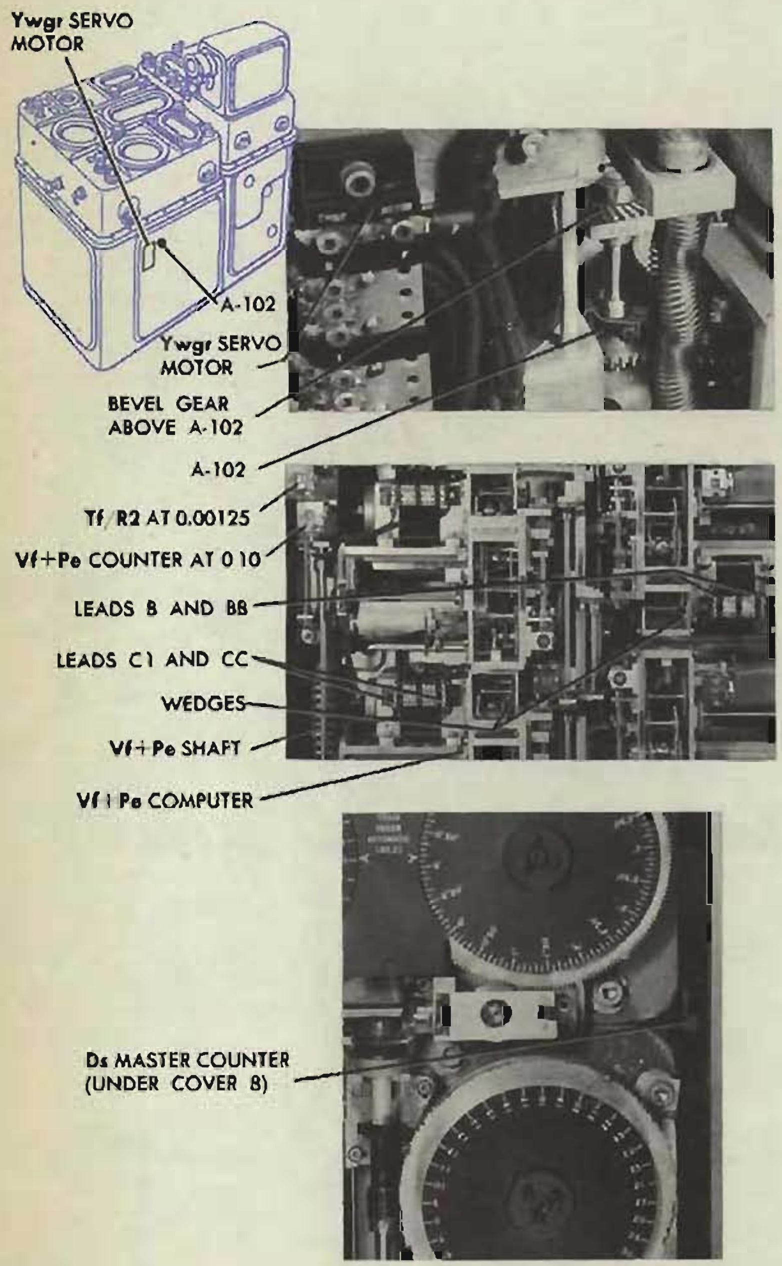
Increase *So* and note the value on the *So* dial at the moment the *Ywgr* follow-up stops driving. Repeat at the lower limit. The *So* dial should read the same value at both limits.

Readjust A-100.





A-102 SYNCHRONIZING THE Dtwj FOLLOW-UP



Location

A-102 is under cover 5, to the rear of the *Ywgr* servo motor.

Check

Remove leads C1 and CC from the *Vf* + *Pe* ballistic computer.
Set the *Vf* + *Pe* counter at 100′ (010) and wedge the follow-up output gearing.

Remove leads B and BB from the *Tf/R2* ballistic computer.
Set the *Tf/R2* counter at 0.00125. (On Mods 8 and 12, set *Tf/R2* at 0.001184.)
Wedge the follow-up output gearing.

Turn the power ON.

Set *So*, *Sh*, and *Sw* at 0 knots.
Set *A*, *Br*, and *Bws* at 0°.
Set *I.V.* at 2550 f.s.
Set *Dj* at 0 mils.

The *Ds* master counter should read 500 mils.

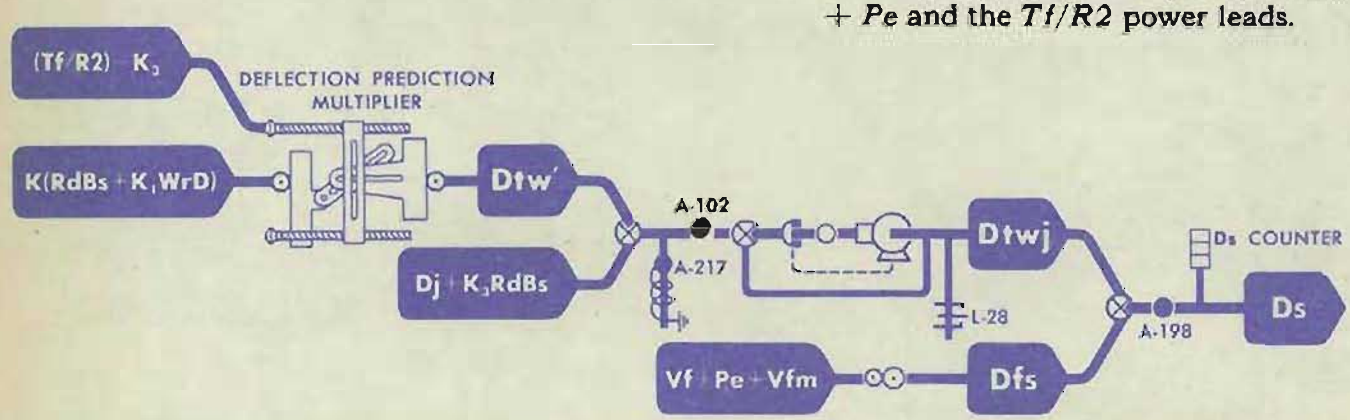
Adjustment

If the *Ds* counter does not read 500 mils, make A-102 slip-tight.

Hold the bevel gear 1½ inches above A-102, and turn the spur gear under A-102 until the *Ds* master counter reads 500 mils.

Tighten A-102 and recheck.

Remove the wedges. Replace the *Vf* + *Pe* and the *Tf/R2* power leads.



A-103 SYNCHRONIZING THE V FOLLOW-UP

Location

A-103 is under cover 5, to the rear of the *V* follow-up, 2 inches in from A-221.

The *Vs* master counter is under cover 6, behind the *Eb* servo motor.

Check

Remove leads C1 and CC from the *Vf* + *Pe* follow-up motor. Set *Vf* + *Pe* at 0 by turning the shaft leading to the counter. Wedge the gearing.

Remove leads B and BB from the *Tf/R2* follow-up motor. Set *Tf/R2* at its lower limit and wedge the line.

Turn the power ON.

Set *So*, *Sh*, *dH*, and *Sw* at 0 knots.
Set *A*, *Br*, and *Bws* at 90°.
Set *Vj* at 0 mils, *Ds* at 500 mils, and *I.V.* at 2550 f.s.

The *Vs* master counter should read 2000′.

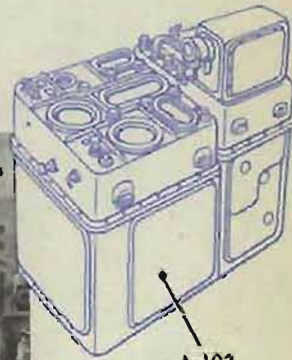
Adjustment

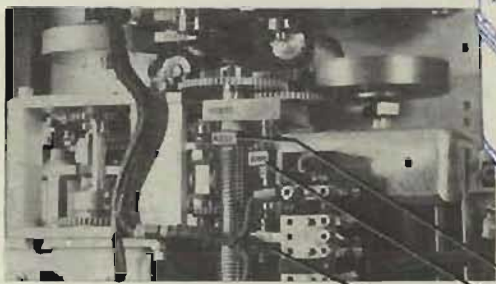
If the *Vs* counter does not read 2000′, make A-103 slip-tight.

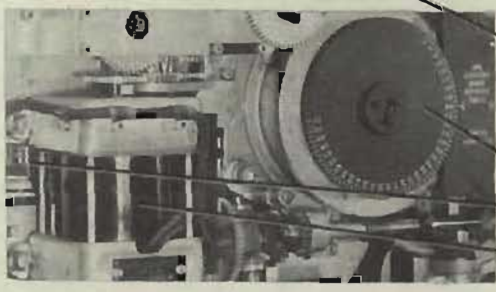
Hold the bevel gear 1½ inches below A-103, and turn the spur gear above A-103 until the *Vs* master counter reads 2000′.

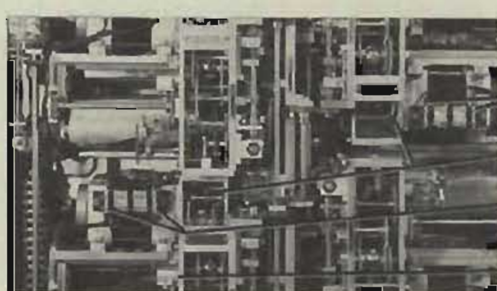
Tighten A-103 and recheck. All quantities must remain at the required values.

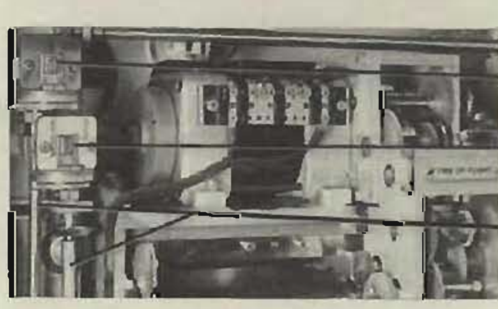
Remove the wedges. Replace the leads on the *Vf* + *Pe* and *Tf/R2* follow-ups.

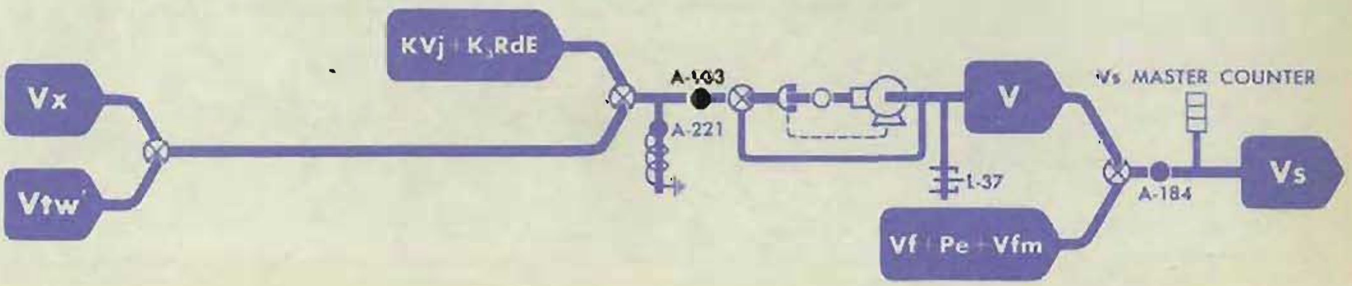




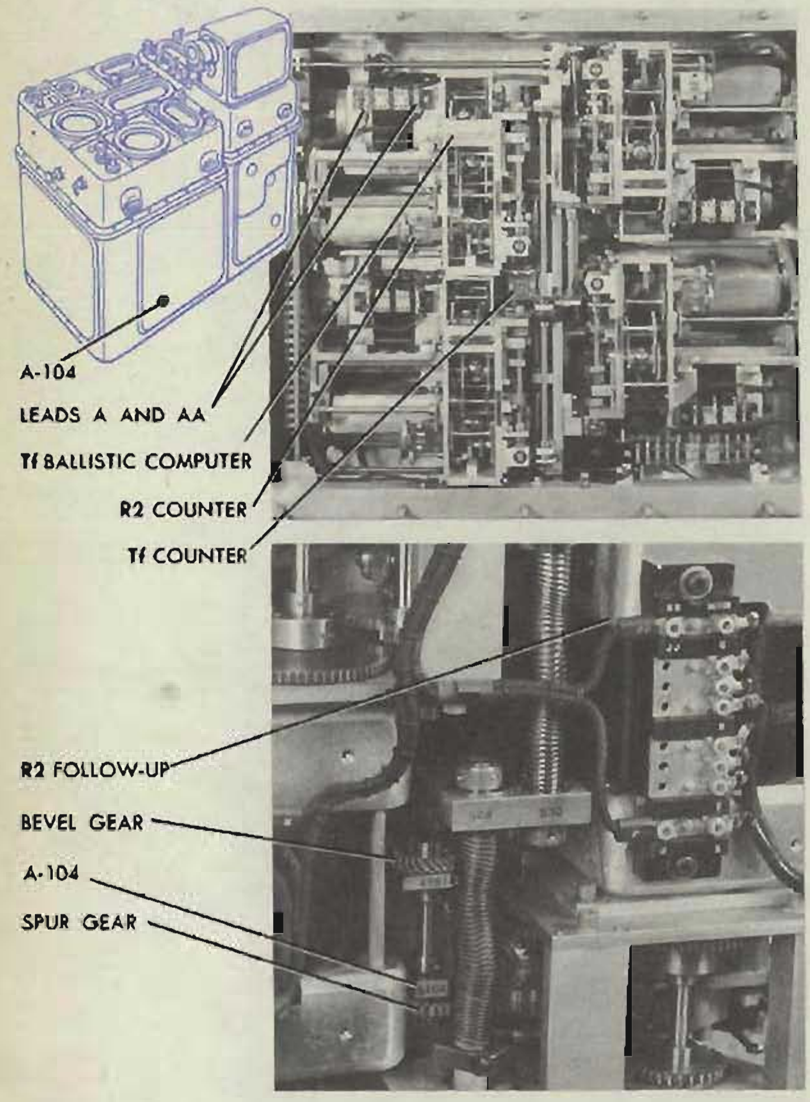








A-104 SYNCHRONIZING THE R2 FOLLOW-UP



Location

A-104 is under cover 5, at the side of the *R2* follow-up.

Check

Turn the power ON.

Set *So*, *Sh*, *dH*, and *Sw* at 0 knots.
Set *I.V.* at 2550 f.s.
Set *A*, *Br*, and *Bws* at 90°.
Set *Rj* at 0 yards.
Set *Tf* at 5 seconds. (On Mods 8 and 12, set *Tf* at 8 seconds.) To set the *Tf* counter, disconnect leads A and AA, and turn the *Tf* follow-up output gearing. Then wedge the line.

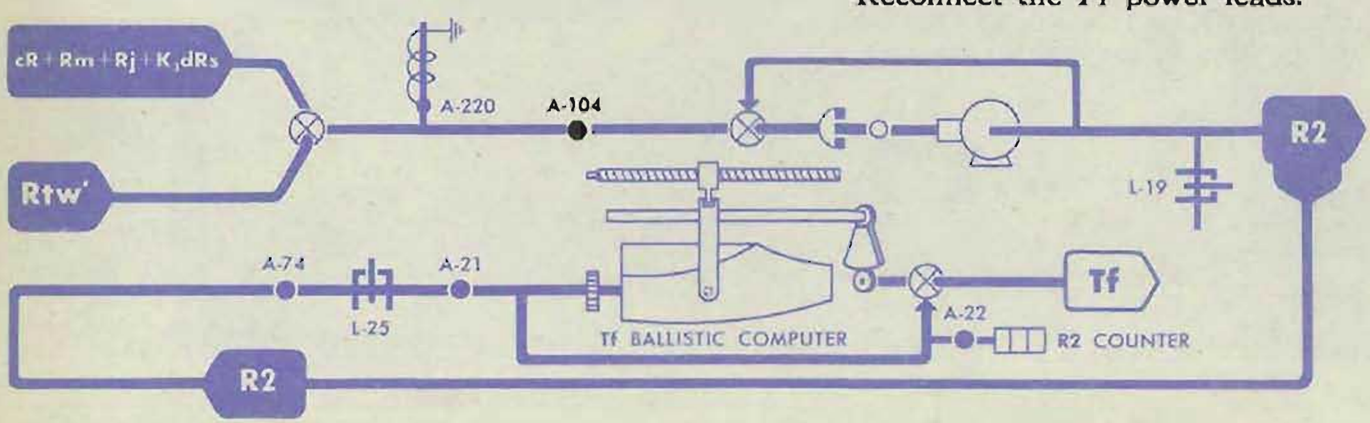
Set *cR* at 10,000 yards.

The *R2* follow-up should be synchronized and the *R2* counter in the *Tf* ballistic computer should read 10,000 yards.

Adjustment

If the *R2* counter does not read 10,000 yards, make A-104 slip-tight. Use a gear pusher to hold the bevel gear 1½ inches above the clamp, and use another gear pusher to turn the spur gear below the clamp, until the master *R2* counter reads 10,000 yards.

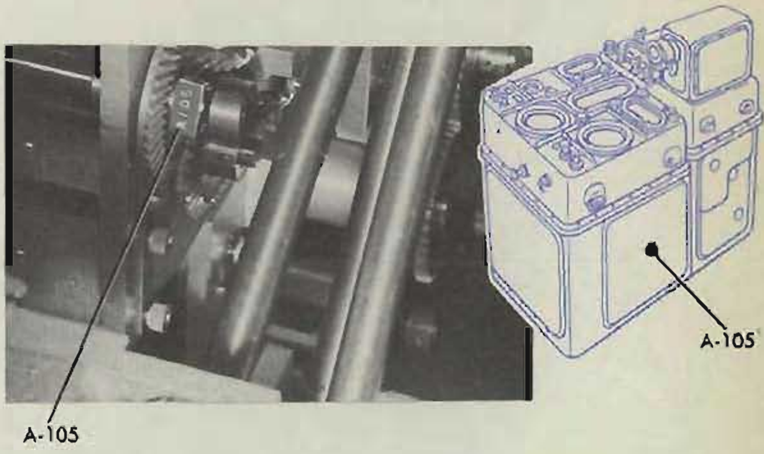
Tighten A-104 and recheck.
Remove the wedge from the *Tf* follow-up output gearing.
Reconnect the *Tf* power leads.



A-105 HORIZONTAL WIND COMPONENT SOLVER to Bws DIAL

Location

A-105 is under cover 5.



Check

Turn the power ON.

Set *Ds* at 500 mils.
Set *B* at 0°.
Set *Bw* at 90°.

The slot in the vector gear of the horizontal wind component solver should be positioned downward.

Mark the *Ywgr* follow-up output gearing for use as an indicator. Turn *Sw* from 0 to 60 knots.

There should be no output from the *Ywg* output rack.

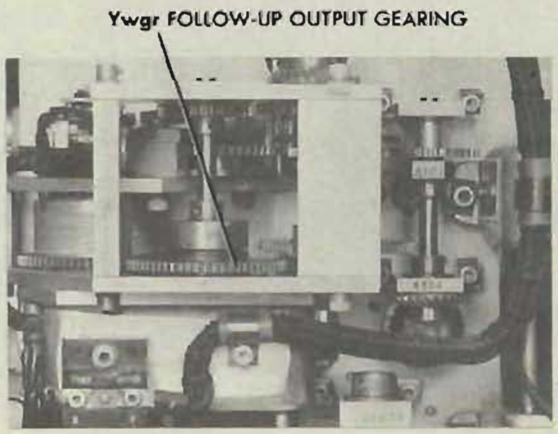
If the slot is correctly positioned, the *Xwg* output rack moves down as *Sw* is increased. The *Ywg* rack should not move.

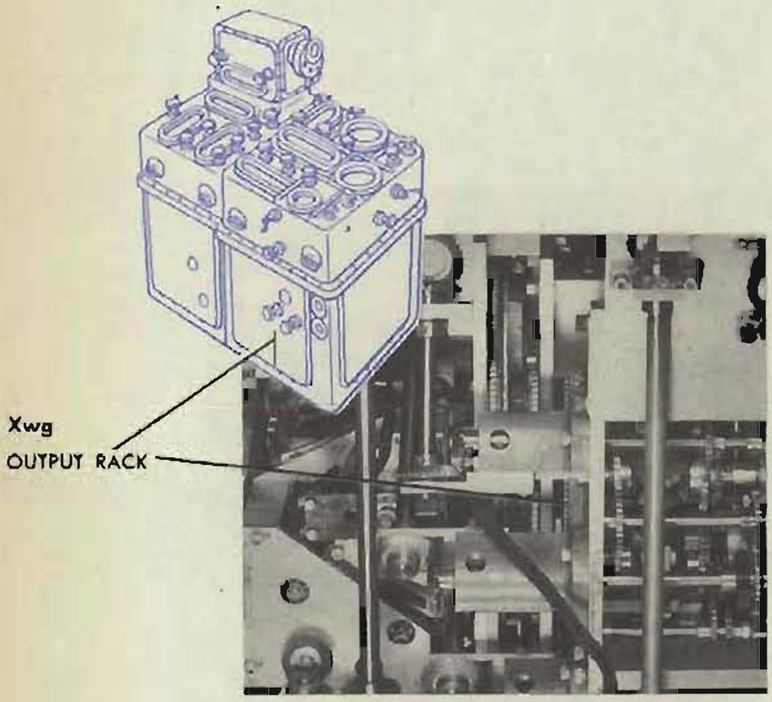
Output on the *Ywg* rack can be checked by movement of the *Ywgr* follow-up output gearing.

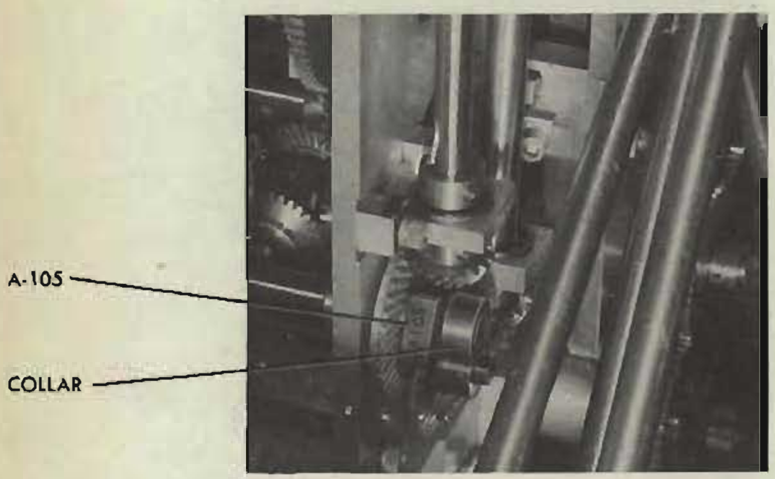
CAUTION

Before making this adjustment, turn *Ywgr* from one limit to the other by means of the *Ywgr* follow-up output gearing with the power OFF.

If there is any interference in the travel of *Ywgr* before the limits are reached, loosen A-100.





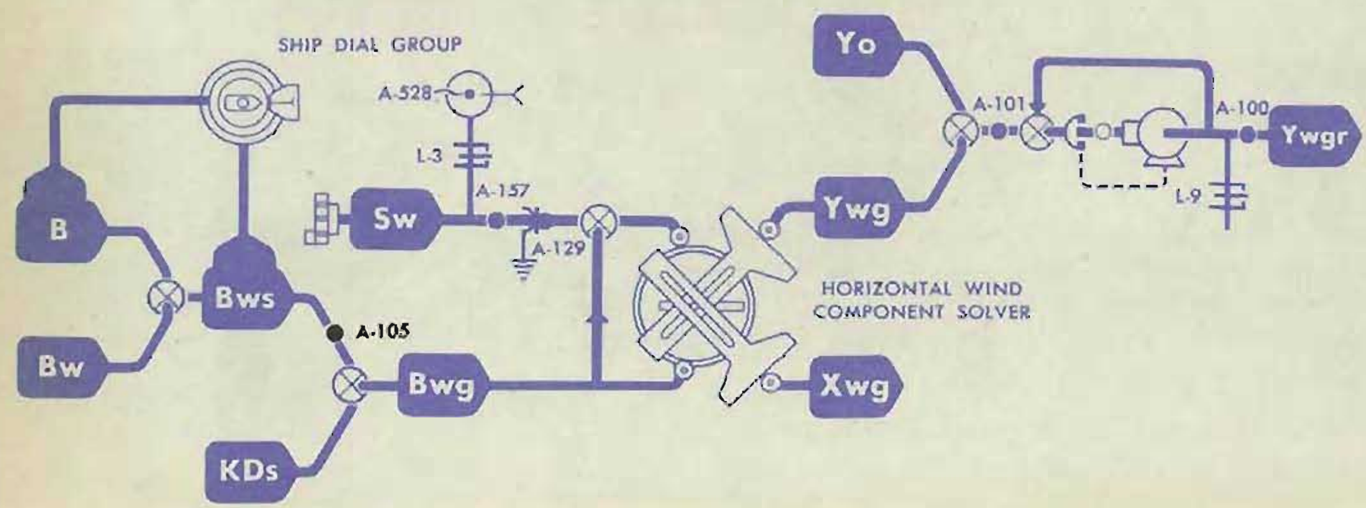


Adjustment

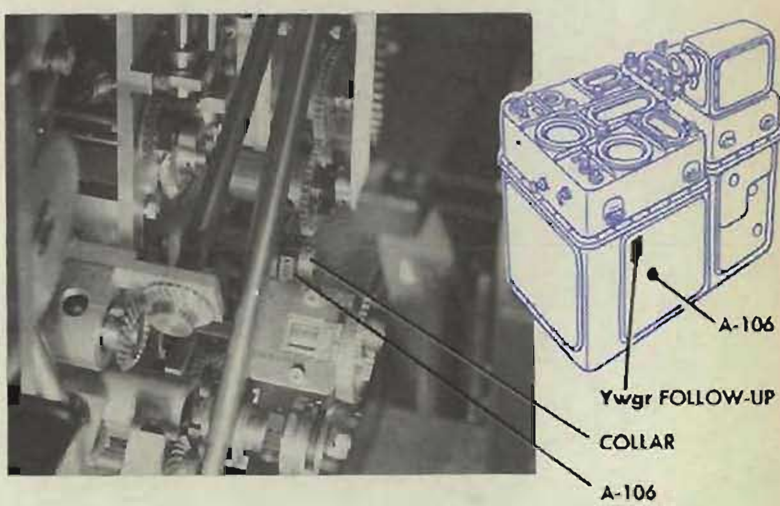
If *Xwg* does not move down, or if there is any output on the *Ywgr* follow-up as *Sw* is increased from 0 to 60 knots, make A-105 slip-tight. Move the vector gear until there is no output of *Ywg* for an input of *Sw*, and until the *Xwg* rack moves down when *Sw* is increased.

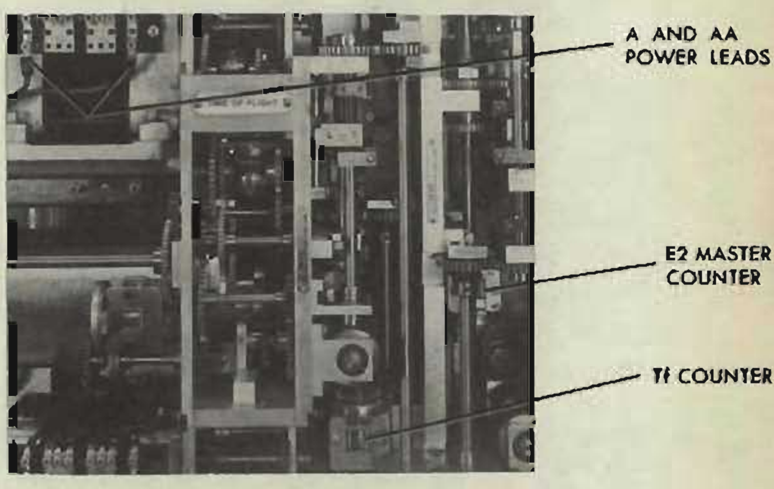
To move the vector gear, turn the collar next to A-105. *Bw* must not move off 90°. Tighten A-105, and recheck.

Check A-101, A-131.



A-106 ELEVATION WIND COMPONENT SOLVER to E2 COUNTER





Location

A-106 is under cover 5, at the lower center.
The *E2* master counter is under cover 4.

Check

Turn the power OFF.

Remove leads F and FF from the *Ywgr* follow-up. Remove leads A and AA from the *Tf* follow-up.

Set *E2* at 0°, with the sync *E* hand-crank at CENTER.
The elevation wind component solver vector gear should be positioned with the gear end of the lead screw at the top.

Set *E2* at 78.947°. (On Mods 8 and 12, set *E2* at 80.496°.)
Turn the *Ywgr* follow-up output line from limit to limit.
There should be no output of the *WrR* rack. The *WrR* rack can be seen from the left side of the instrument.
If there is any apparent motion of the *WrR* rack, A-106 should be readjusted.

Adjustment

Loosen A-106. Turn the collar next to A-106 to position the vector gear, with the gear end of the lead screw toward the right of the instrument, until there is no output on the *WrR* rack for the entire travel of *Ywgr*.
Tighten A-106.

Refining the adjustment

Turn the power ON.

Set *Tf* at its upper limit and wedge the gearing.

Set *E2* at 78.947°. (On Mods 8 and 12, set *E2* at 80.496°.)

Turn the *Ywgr* follow-up output gearing to one limit.

Mark a gear in the *R2* follow-up output gearing as an indicator.

Turn *Ywgr* to the other limit. If the *R2* indicating gear moves more than 2 teeth, loosen A-106. Turn the collar next to the clamp until the indicating gear has returned halfway to its original position. Tighten A-106 and recheck.

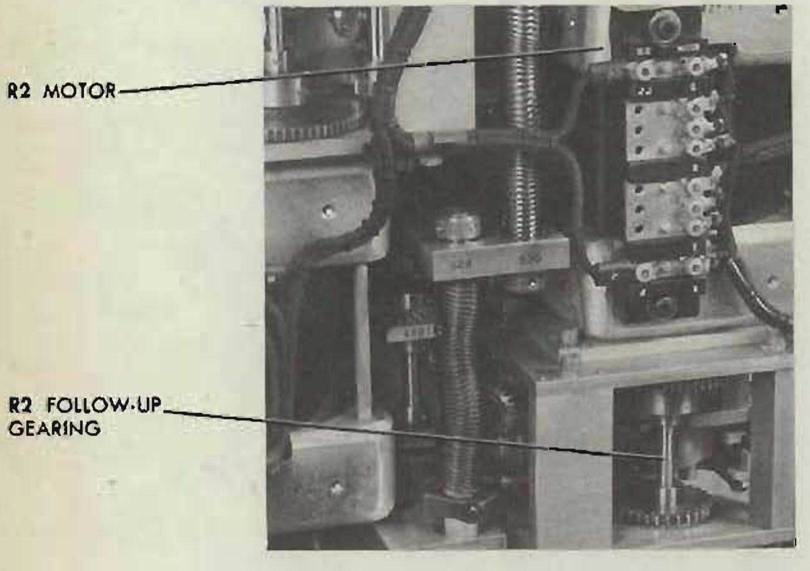
Check that E2 is at 78.947°. (On Mods 8 and 12, check that *E2* is at 80.496°.) Check that the gear end of the lead screw is toward the right.

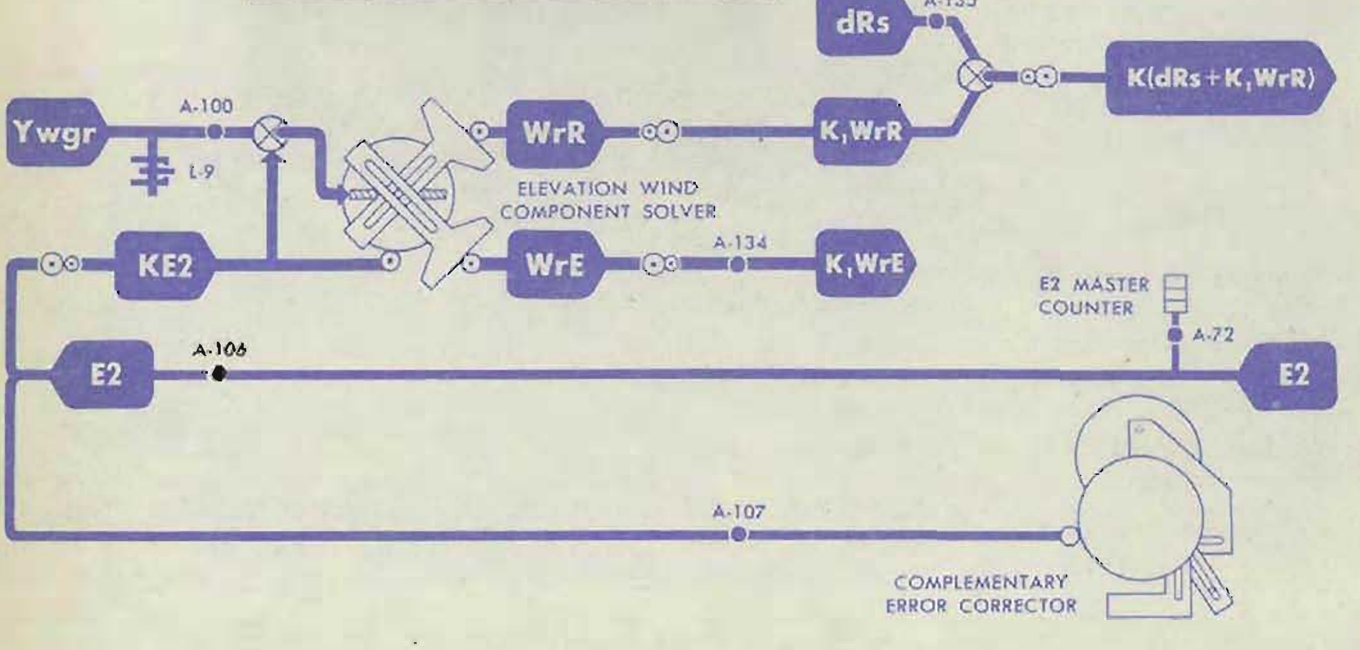
Turn the power OFF.

Remove the wedge from the *Tf* gearing.

Reconnect the leads on the *Ywgr* and *Tf* follow-ups.

Check A-134 and A-135.

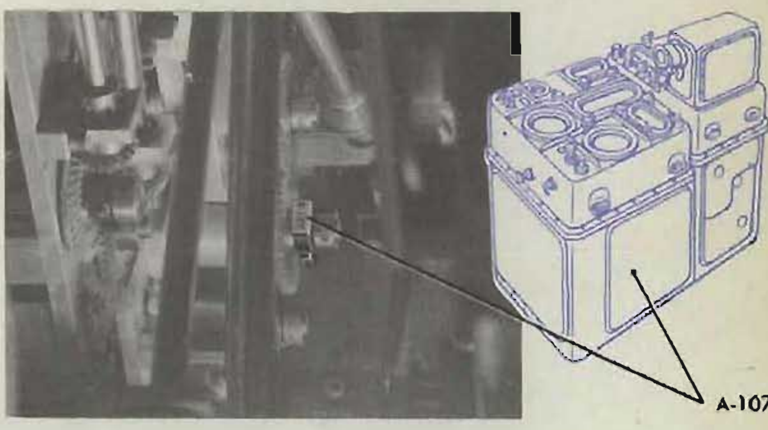




A-107 COMPLEMENTARY ERROR CORRECTOR to E2 COUNTER

Location

A-107 is under cover 5, 20 inches in from the side, and 2 inches above the deck plate.

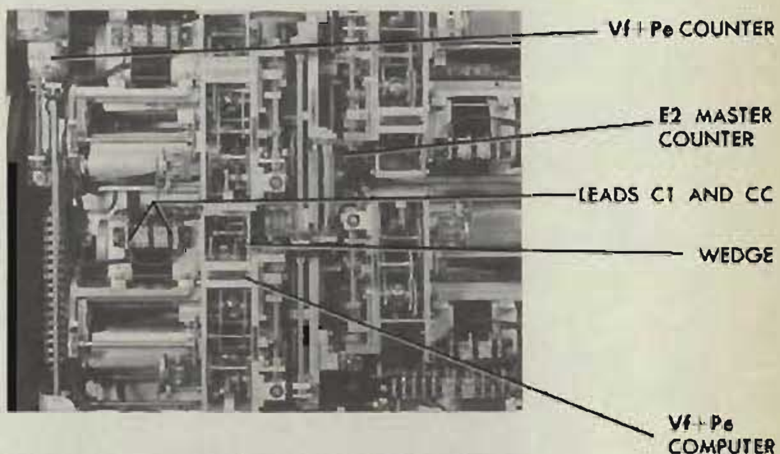


Check

Turn the power ON.

Set $I.V.$ at 2550.
Set So, Sh, Sw, and dH at 0 knots
Set Vj at 0.
Set Ds at 500 mils.

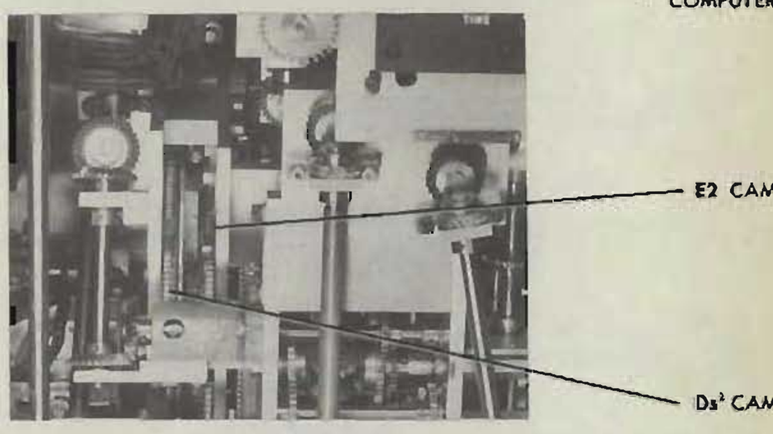
Remove leads C1 and CC from the $Vf + Pe$ follow-up. Set the $Vf + Pe$ counter at 0 and wedge the line.



Set the $E2$ master counter at 80°, with the sync E handcrank at CENTER.
Pull the Vs handcrank OUT. The Vs counter should read 2000'. (If it does not, check A-103.)
Set Ds at 100 mils or 900 mils.
The $E2$ master counter should read 67.25° (±0.05°).

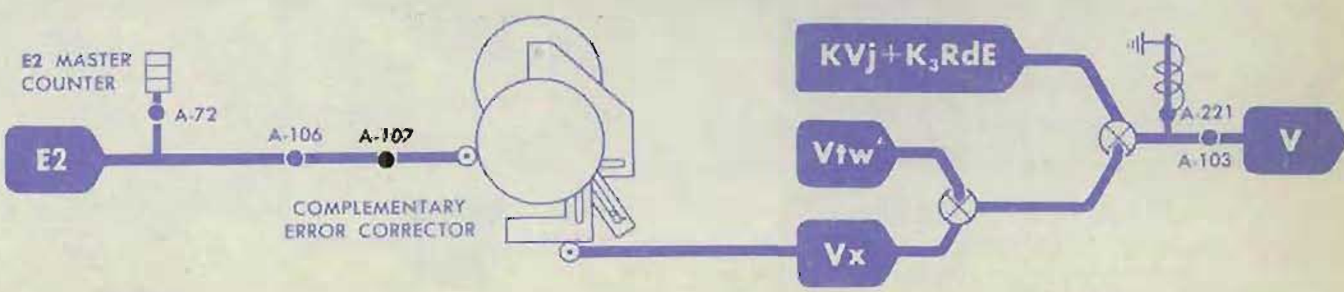
Adjustment

If the $E2$ counter does not read 67.25° (±0.05°), slip-tighten A-107. Turn the $E2$ cam until the counter reading is correct. Tighten A-107 and recheck.



Remove the wedge.
Replace the $Vf + Pe$ power leads.

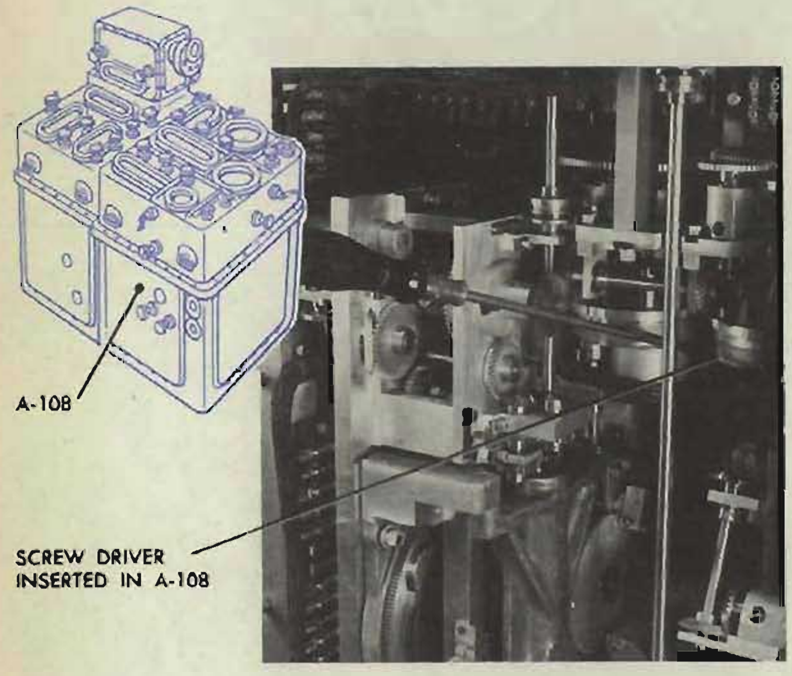
Check A-103.



A-108 and A-109

A-108 RANGE RATE CORRECTOR to RdE LINE

A-109 RANGE RATE CORRECTOR to RdBs LINE



Location

A-108 is under cover 3 at the left center of the front pedestal section. It is above the coupling on a diagonal shaft, and can be reached by a long screw driver.

A-109 is under cover 5. It is above the coupling on a vertical shaft.

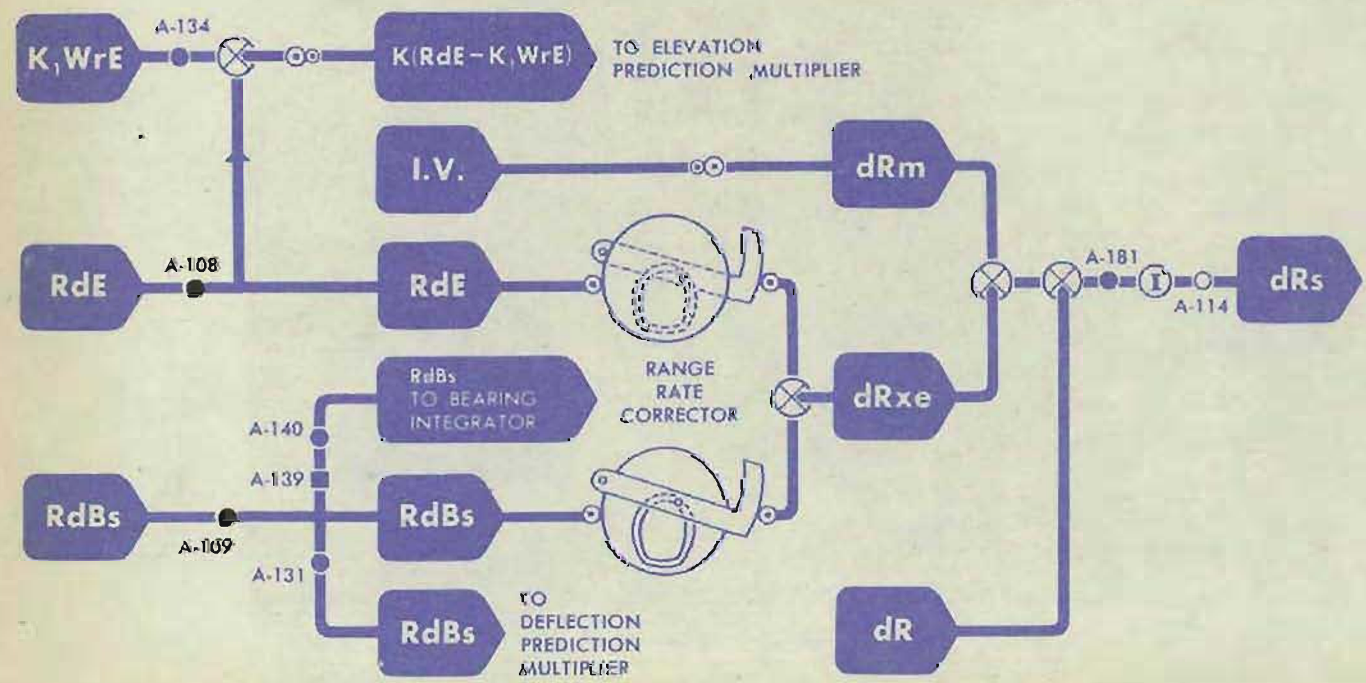
The range rate corrector is under cover 5, behind the mounting plate of the *R2* follow-up. The range rate corrector can be reached by hand.

Check

Turn the power ON.

Set *So* and *Sh* at 0 knots.
Set *dH* at 0 knots.

Both the *RdE* and *RdBs* lines are now at their zero positions and MUST REMAIN SO POSITIONED during this check and adjustment.



The $RdBs^2$ cam and the RdE^2 cam of the range rate corrector should now be at their zero positions, where a 1/16-inch setting rod can be inserted through the hole in both followers and cams and the mounting plate between them.

Adjustment

If the rod goes through the RdE^2 cam follower, but cannot continue through the RdE^2 cam, loosen A-108. Move the RdE^2 cam until the rod can be inserted. Tighten A-108. The hole in the RdE^2 cam is in the section of the cam groove closest to the center of the cam.

With the rod through the RdE^2 cam, try to insert it through the $RdBs^2$ cam. If it cannot be inserted, loosen A-109. Turn the input to the $RdBs^2$ cam until the rod can be inserted through the holes in the $RdBs^2$ follower and cam. Tighten A-109. The rod will go in approximately 2 inches when inserted through both cams and both followers.

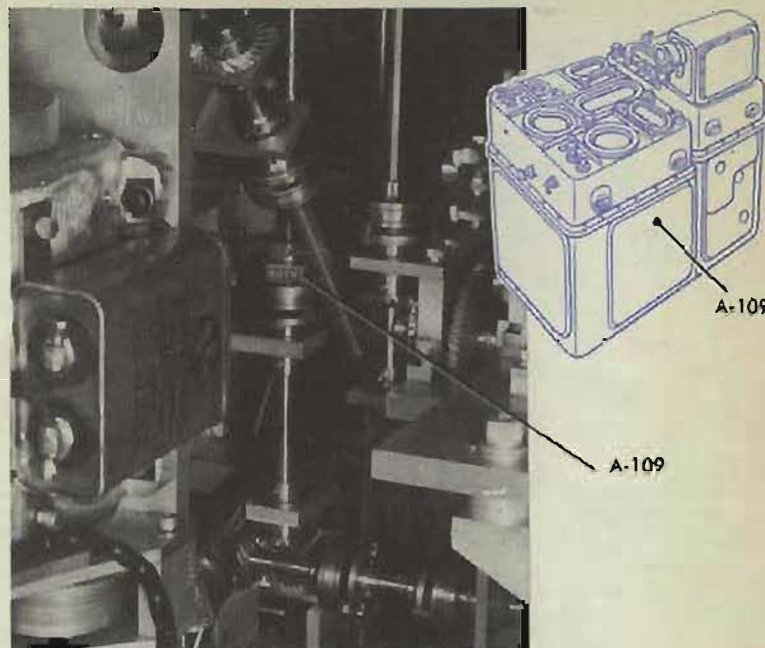
REMINDER: Remove the setting rod.

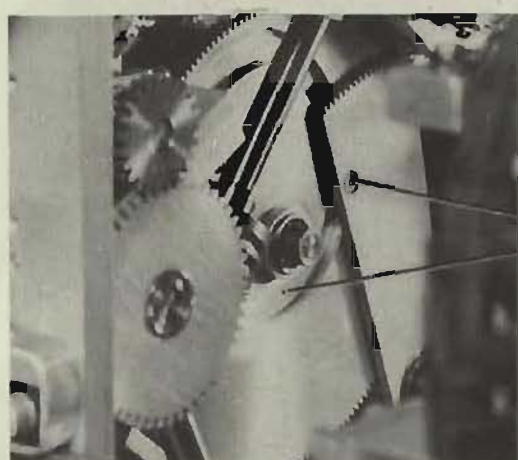
Check the *RdBs* and *RdE* lines for restrictions or interference by turning the power OFF and turning the output gearing of the *RdBs* and *RdE* follow-up by hand from one limit to the other. This must be done because the adjustments of A-109 and A-108 control the *RdBs* and *RdE* inputs to other units.

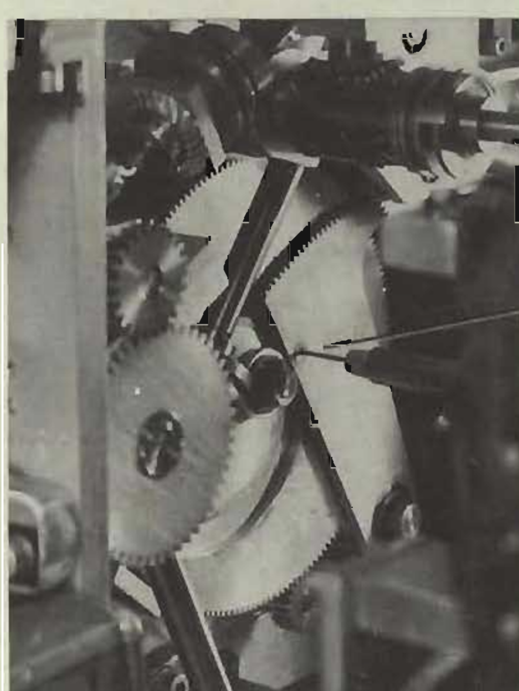
CAUTION

Do not turn any handcranks while the setting rod is in the cams. Remove the rod immediately on completion of the adjustment or serious damage will result.

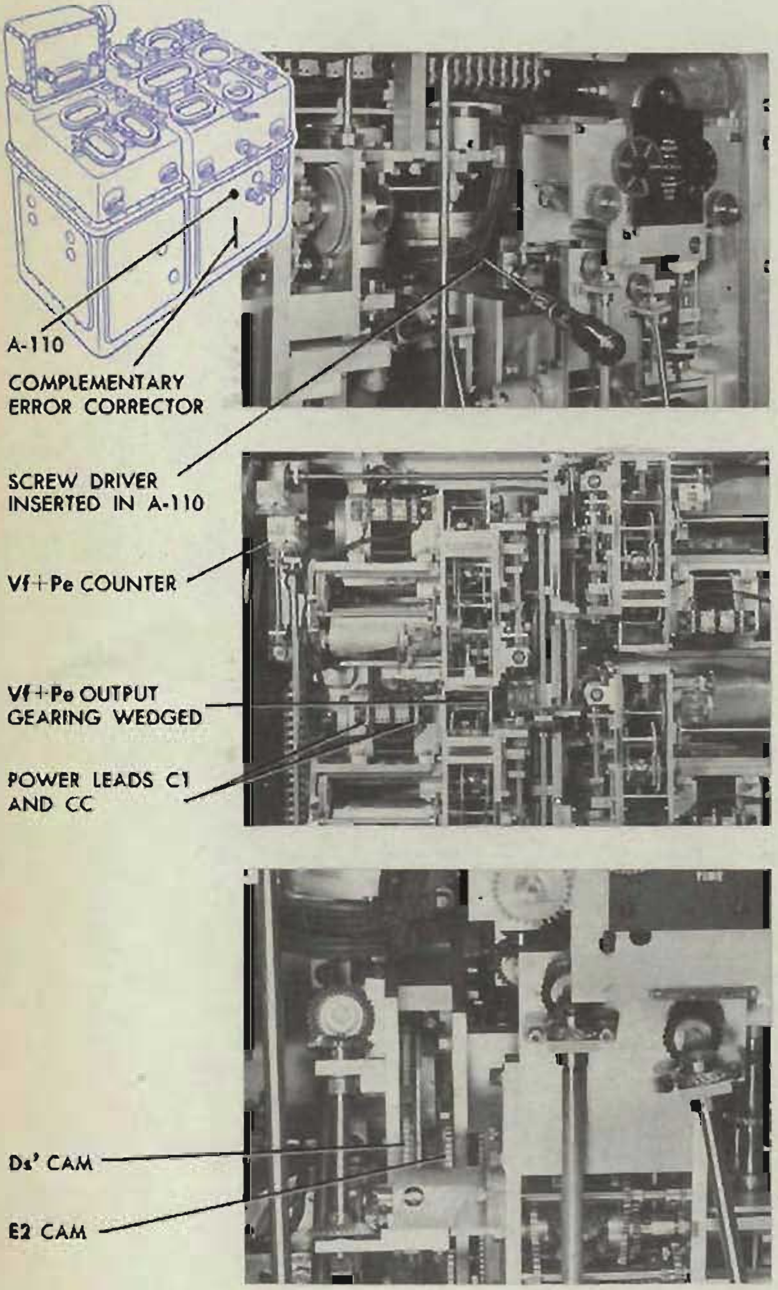
If A-108 is readjusted, check A-134 and A-181. If A-109 is readjusted, check A-131, A-139, A-140, and A-181.







A-110 COMPLEMENTARY ERROR CORRECTOR to Ds COUNTER



Location

A-110 is under cover 3, 10 inches from the top, 14 inches in from an access behind the *I.V.* dial.

Check

Remove leads C1 and CC from the *Vf* + *Pe* follow-up. Set the *Vf* + *Pe* counter at 0 and wedge the line.
Turn the power ON.
Set *I.V.* at 2550.
Set *So*, *Sh*, *Sw*, and *dH* at 0 knots. Set *Vj* at 0.

Set *Ds* at 500 mils.
Set *E2* at 80°, with the sync *E* handcrank at CENTER.
Pull the *Vs* handcrank OUT. The *Vs* indicating counter should read 2000'. (If it does not, check A-103.)

Set *Ds* at 100 mils and read the *Vs* counter.
Set *Ds* at 900 mils and read the *Vs* counter.
Vs should have *increased*, and then *decreased* to the same reading that was shown when *Ds* was at 100 mils.

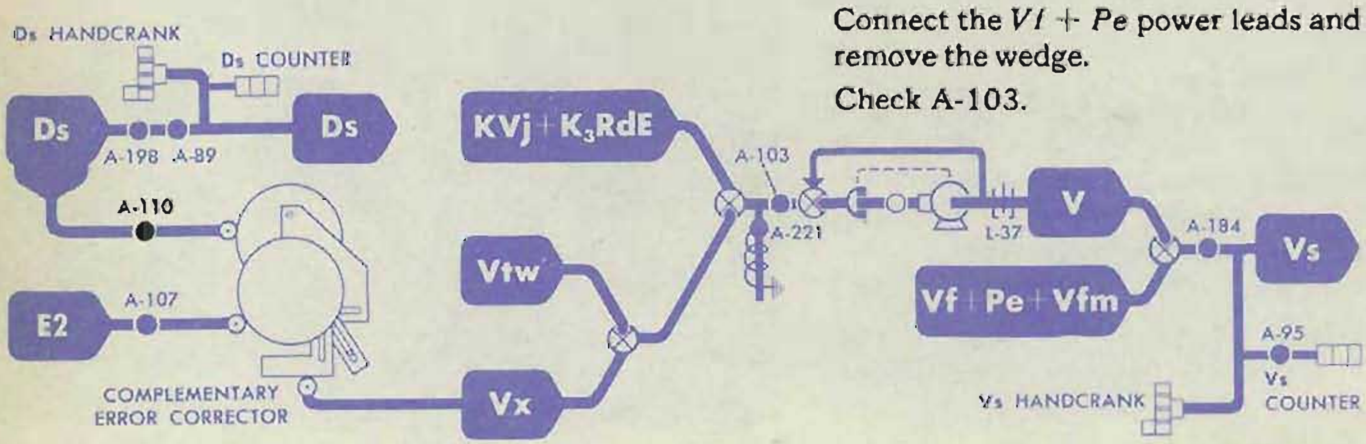
Adjustment

If the *Vs* counter does not read the same with *Ds* at 100 and 900 mils, slip-tighten A-110. Turn the *Ds'* cam until an equal value of *Vs* is obtained for *Ds* settings of 100 and 900 mils. *Vs* should *decrease* when *Ds* is either increased or decreased from 500 mils.

Tighten A-110 and recheck.

Connect the *Vf* + *Pe* power leads and remove the wedge.

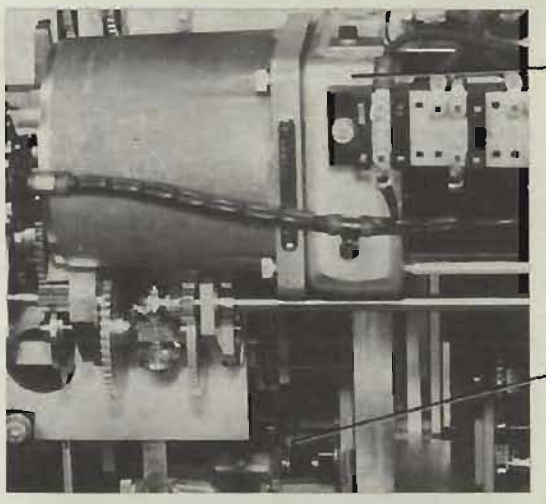
Check A-103.

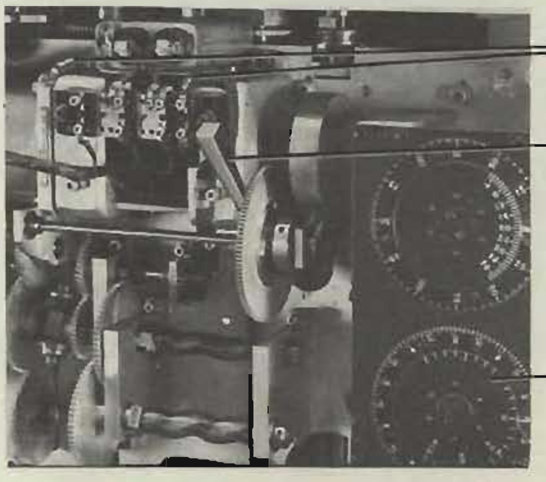


A-111 Zd (L - L cos 2B'r) MULTIPLIER to Zd DIALS

Location

A-111 is under cover 7, below the *Vz* motor.





Rough check

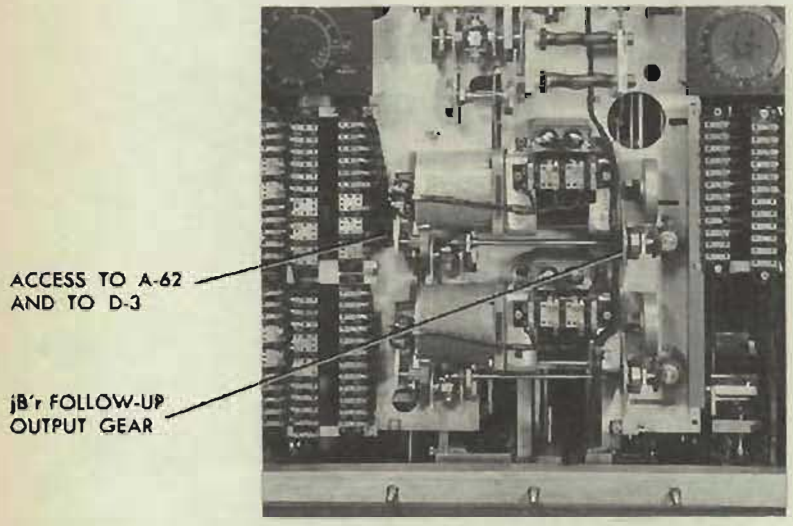
Set *Dd* at 0.
Remove leads 1B and 1BB from the *Dd* follow-up. Wedge the output gearing.
Turn the power ON.
Turn the control switch to SEMI-AUTO.
At the switchboard, turn off the *B'r* receiver switch.
Set *Zd* at 2000' and wedge the line.
Set *B'gr* at 90°.

The *Zd* input to the multiplier should be at its zero position. Full travel of *L* should cause no motion of the output slide of the multiplier.

Motion of the output slide can be seen on the spider of D-3, in front of the *jB'r* contact assembly.

Refined check

Remove leads 1B and 1BB from the *Dd* follow-up. Set the *Dd* dials at 0° and wedge the output gearing.
Turn the power ON.
At the switchboard, turn off the *B'r* receiver switch.
Turn the control switch to SEMI-AUTO.
Set *Zd* at 2000'.
Set *B'gr* at 90°.
Set *L* at 2000'.
Loosen A-62 and wedge the gear on which the clamp is located.



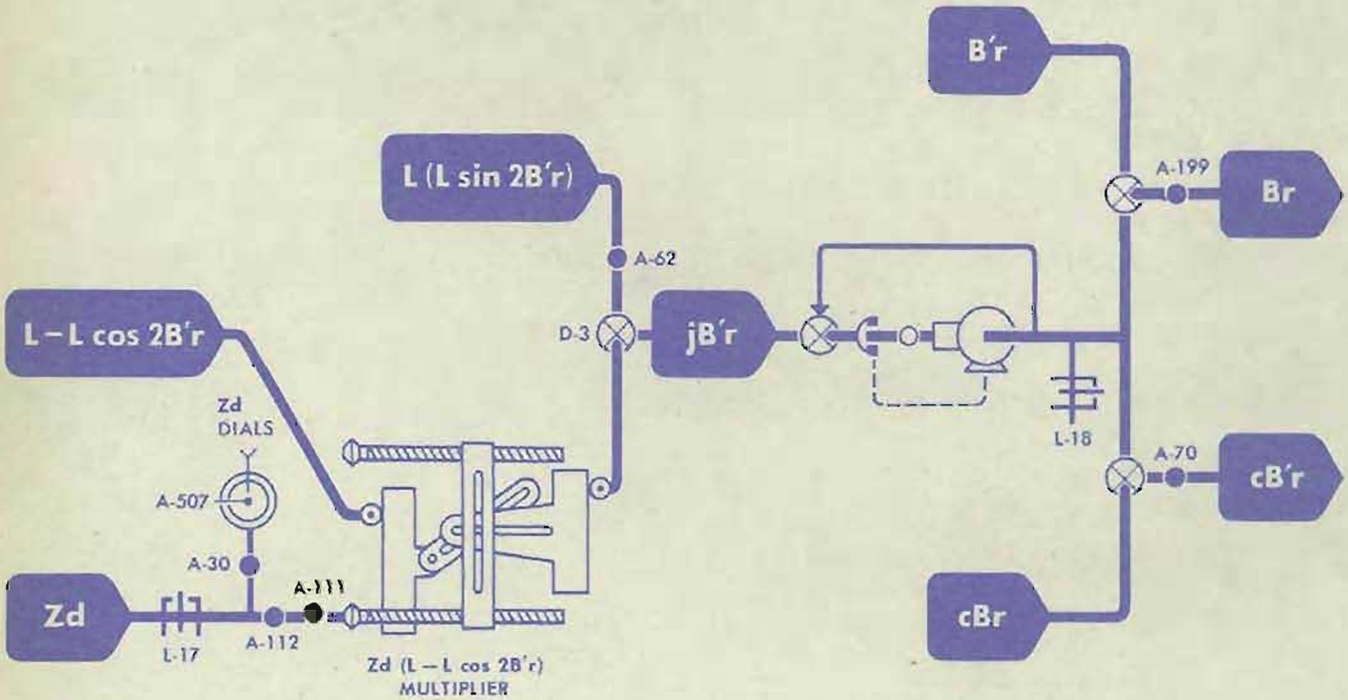
Mark the *jB'r* follow-up output gear as an indicator.
Turn *L* to 3500'.
The indicating mark should not move more than one tooth.

Adjustment

If the indicating mark moves more than one tooth, loosen A-111. Hold *Zd* at 2000', and move the bevel gear next to A-111 with a gear pusher until the marks match. Tighten A-111, and recheck with *L* at 500'.

Remove the wedges and reconnect the leads to the *Dd* follow-up.

Readjust A-62.



A-112 $Zd^2 \tan (Eb+Vs)$ MULTIPLIER to Zd DIALS

Location

A-112 is under cover 7, and can be reached through the opening below the *Vz* servo motor.

Check

Turn the power ON.

Set *Vs* at 2000′.
Set *Ds* at 500 mils.
Set *E* at 60° with the sync *E* handcrank at CENTER.
Match the sync *E* dials at the fixed index with the handcrank OUT.

Increase *Zd* to 3200′, and read *Vz*. The reading on the *Vz* dials should be positive.

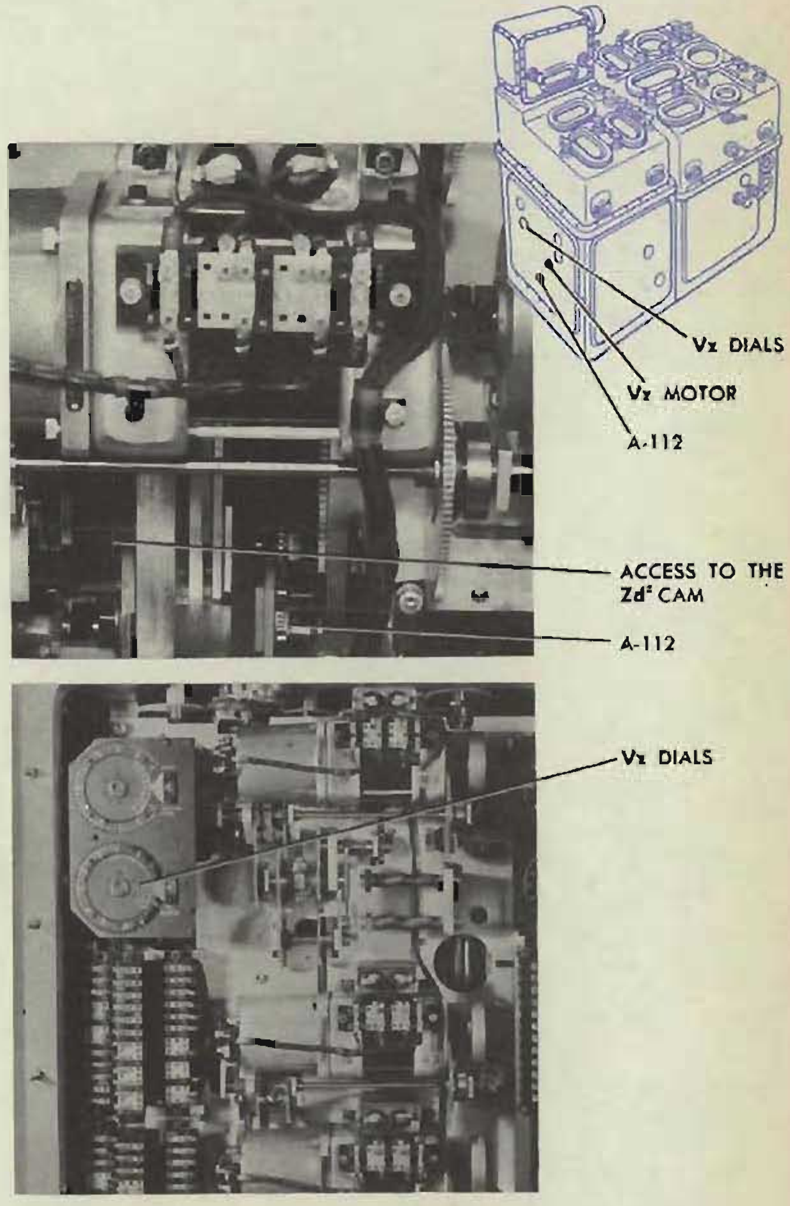
Decrease *Zd* to 800′. The reading on the *Vz* dials should be the same positive value as before.

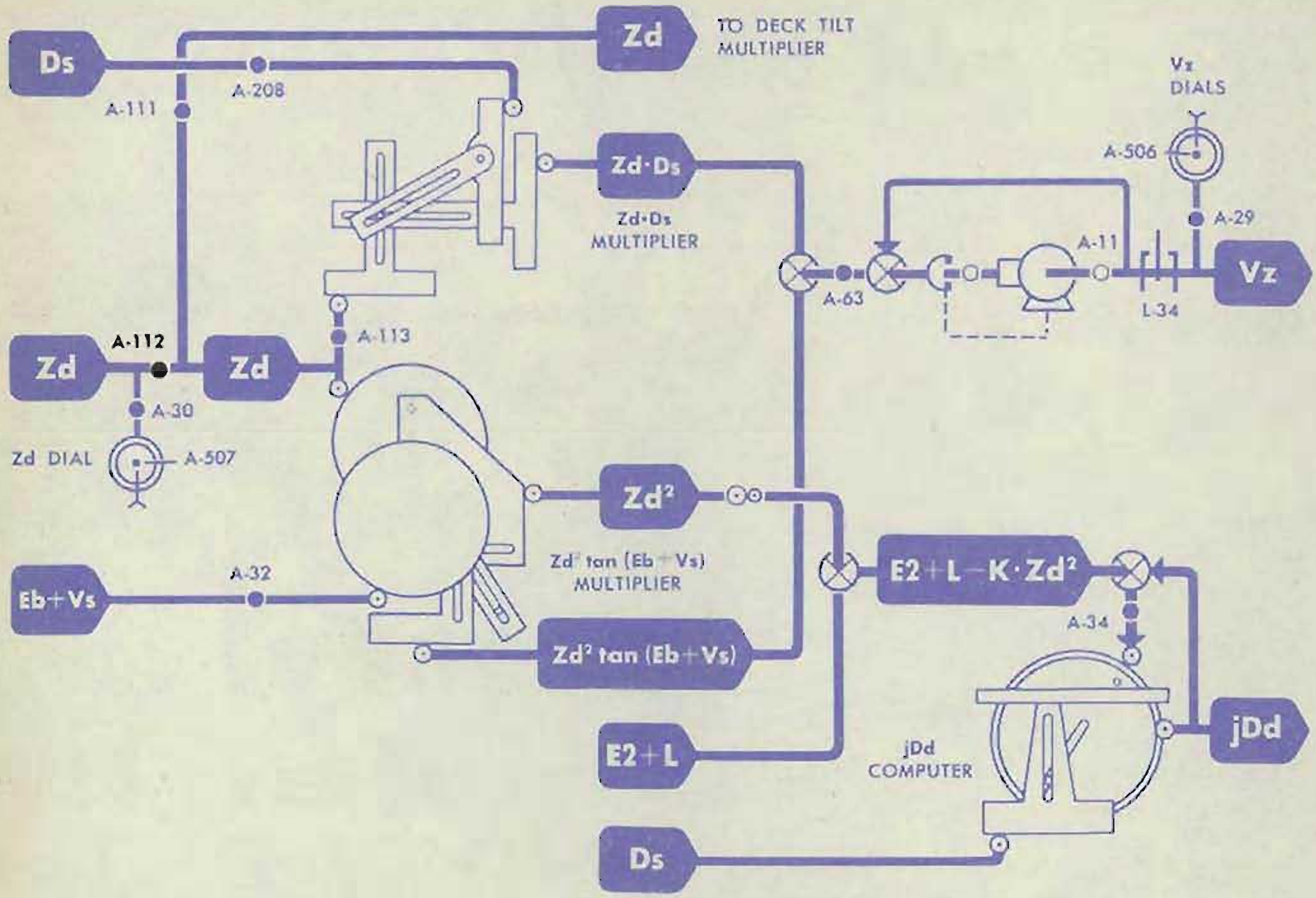
If *Vz* has different values, or if it is negative, A-112 is in error and should be readjusted.

Adjustment

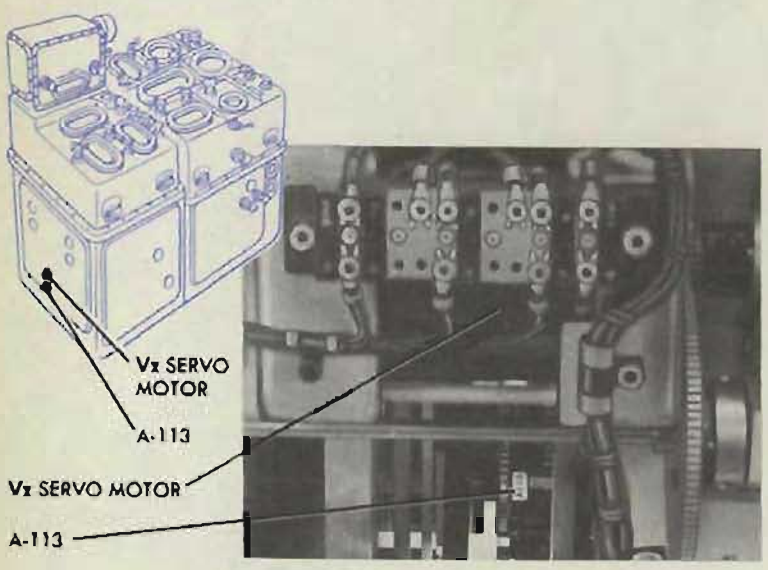
The Zd^2 cam should be adjusted to obtain the same positive output for equal plus and minus inputs of *Zd*.
The Zd^2 cam can be reached through the opening 3 inches to the right of A-112.
Slip-tighten A-112.
Adjust the position of the Zd^2 cam, by slipping through A-112, until equal positive readings are obtained on the *Vz* dials when *Zd* is at 800′ or 3200′.

Tighten A-112, and recheck.
Check A-111, A-113, A-63, and A-32.





A-113 Zd·Ds MULTIPLIER to Zd DIALS



Location

A-113 is under cover 7. It can be reached through the opening below the *Vz* servo motor.

Check

Turn the power ON.

Set *Zd* at 2000′.

Full travel of *Ds* should produce no motion of the output rack of the *Zd* · *Ds* multiplier.

Motion of the *Zd* · *Ds* output rack may be observed on the *Vz* dials.

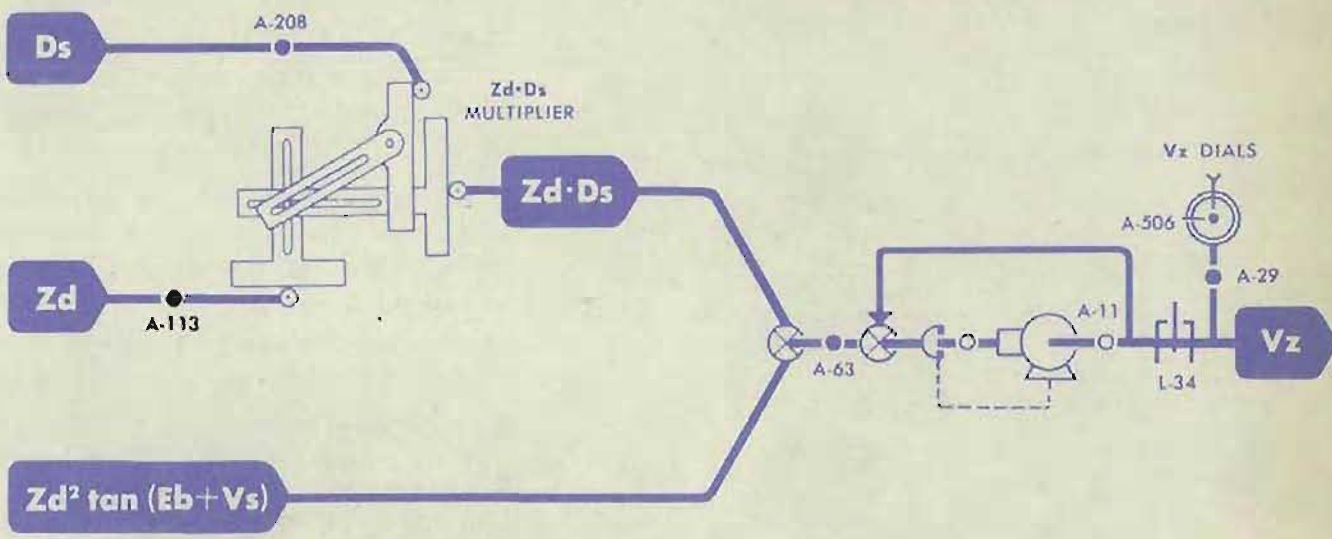
Adjustment

Make A-113 slip-tight.

Adjust the *Zd* input slide by turning the *Zd* input shaft until the 0 position is obtained. At the 0 position, the *Vz* dials show no motion for full travel of the *Ds* input.

Tighten A-113, and recheck.

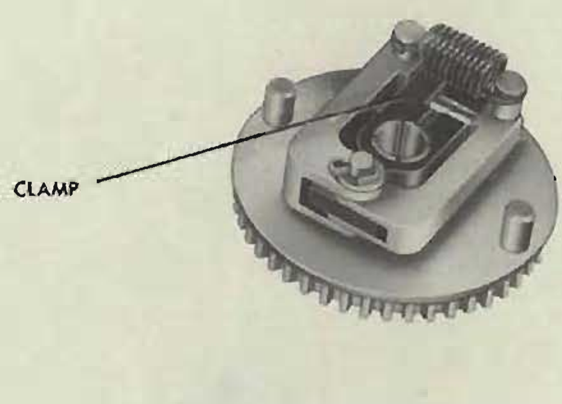
Check A-63.



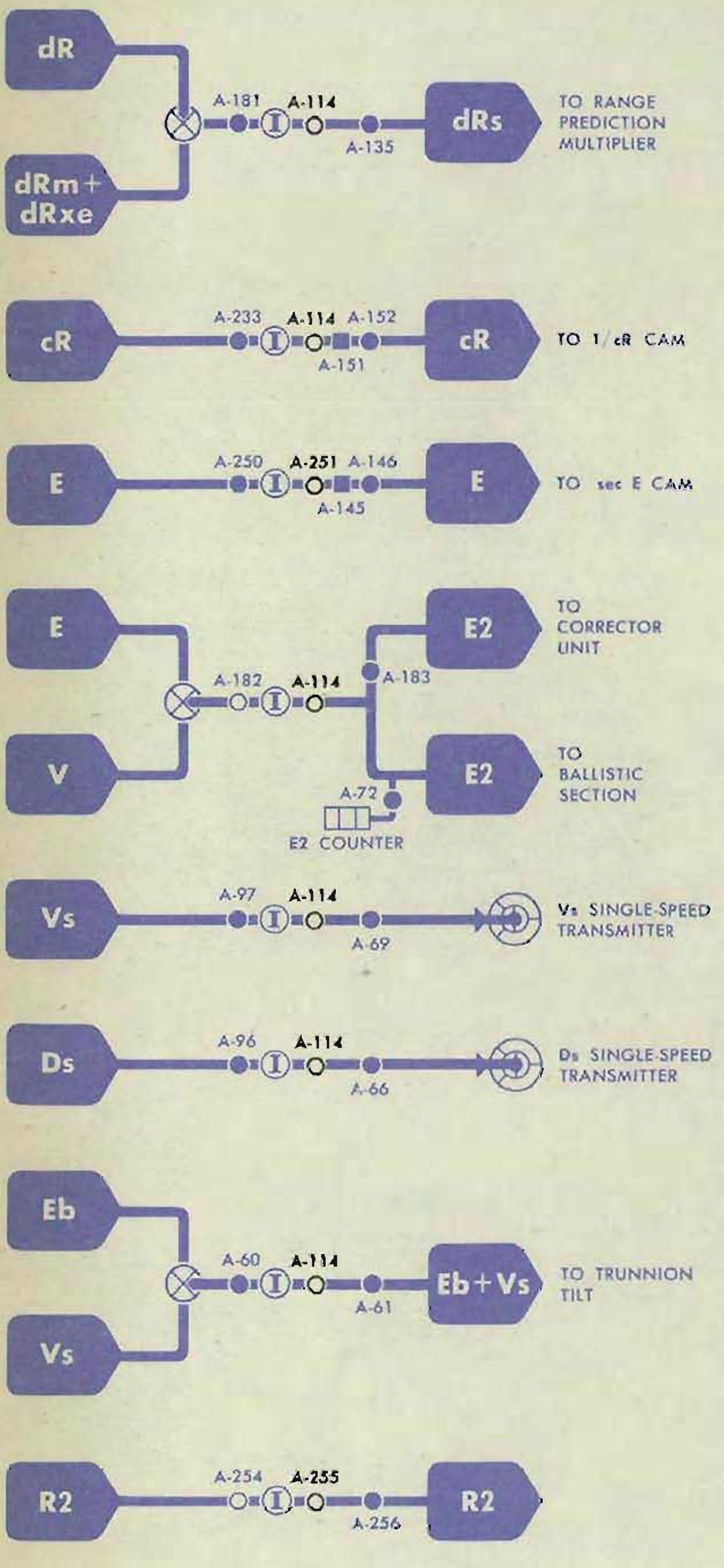
A-114 ASSEMBLY CLAMPS

A-114 is an assembly clamp in a shock absorber assembly on intermittent drive output shafts. It is used on the *dRs*, *cR*, *Eb* + *Vs*, *E2*, *Ds*, and *Vs* intermittent drives.

On the *E* intermittent drive, this assembly clamp is numbered A-251.
On the *R2* intermittent drive, this assembly clamp is numbered A-255.
The *Ds* and *Vs* intermittent drives are omitted on Mods 1, 3, 4, 8, and 12.
The *R2* intermittent drive is omitted on Mods 0, 1, 2, 3, 4, 6, 7, 9, 10, and 13.
The *E* intermittent drive is omitted on all mods with Ser. Nos. 389 and lower.
The *cR* intermittent drive is omitted on Mods 0, 1, 2 and 9.



SHOCK ABSORBER ASSEMBLY



Location

dRs	—see A-181
cR	—see A-233
E	—see A-250
E2	—see A-182
Ds	—see A-96
Vs	—see A-97
Eb + *Vs*	—see A-60
R2	—see A-256

Check

If an intermittent drive output is incorrect, the shock absorber clamp may have slipped. (See *Locating Casualties—Intermittent Drives*, page 552.)

If the output gearing of the intermittent drive can be turned beyond the spring action of the shock absorber when the intermittent drive is in a cut-out position, the shock absorber clamp is slipping.

Adjustment

A-114 on the *dRs* intermittent drive: Tighten A-114 and readjust A-135.

A-114 on the *cR* intermittent drive: Tighten A-114 and readjust A-151.

A-251 on the *E* intermittent drive: Tighten A-251 and readjust A-145.

A-114 on the *E2* intermittent drive: Tighten A-114 and readjust A-72 and A-183.

A-114 on the *Ds* intermittent drive: Tighten A-114 and readjust A-66, or adjust A-114 in accordance with the procedure for A-66.

A-114 on the *Vs* intermittent drive: Tighten A-114 and readjust A-69, or adjust A-114 in accordance with the procedure for A-69.

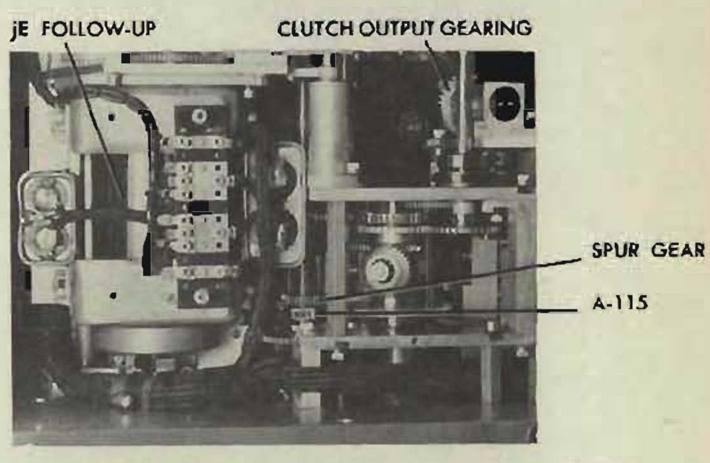
A-114 on the *Eb* + *Vs* intermittent drive: Tighten A-114 and readjust A-61.

A-255 on the *R2* intermittent drive: Tighten A-255 and readjust A-256.

A-115 ELEVATION COMPONENT INTEGRATORS to E DIALS

Location

A-115 is under cover 1, at the left side.



Check

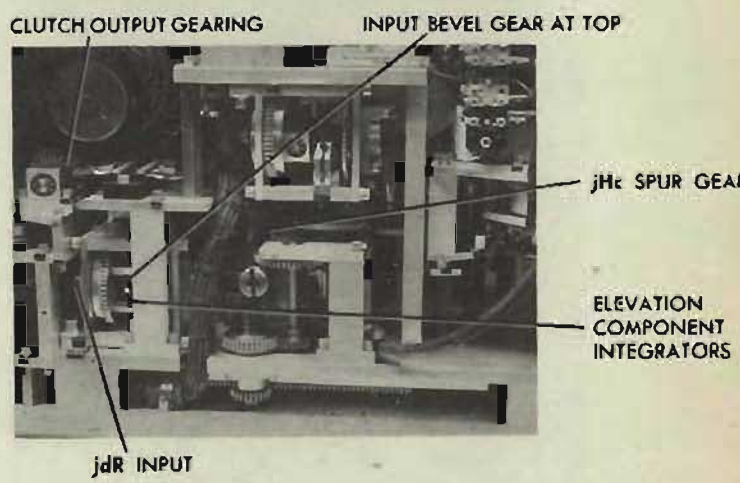
Turn the power OFF.

Set *E* at 0°.

Turn the *jdR* input line at the output gearing of the clutch, 1 inch to the rear and above the elevation component integrator.

The *jdR* input bevel gear of the elevation component integrator should be at the top of the driving roller.

There should be no motion of the *jHc* output when the *jdR* line is turned. Any motion of *jHc* can be checked on the small spur gear in front of the component integrator about 2 inches in and on the right side of the *dH* input gear hanger.



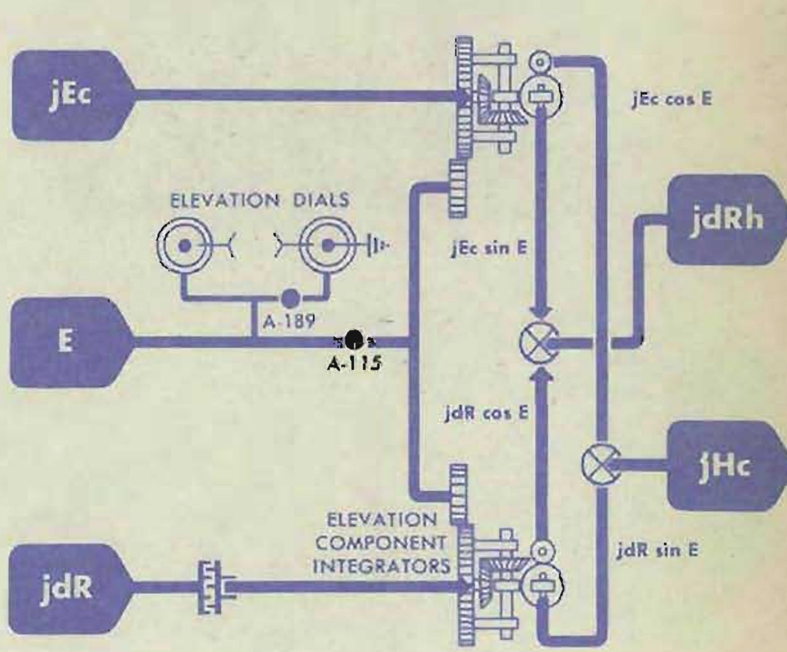
Adjustment

If the bevel gear is not at the top of the driving roller, and if there is any motion of *jHc*, make A-115 slip-tight.

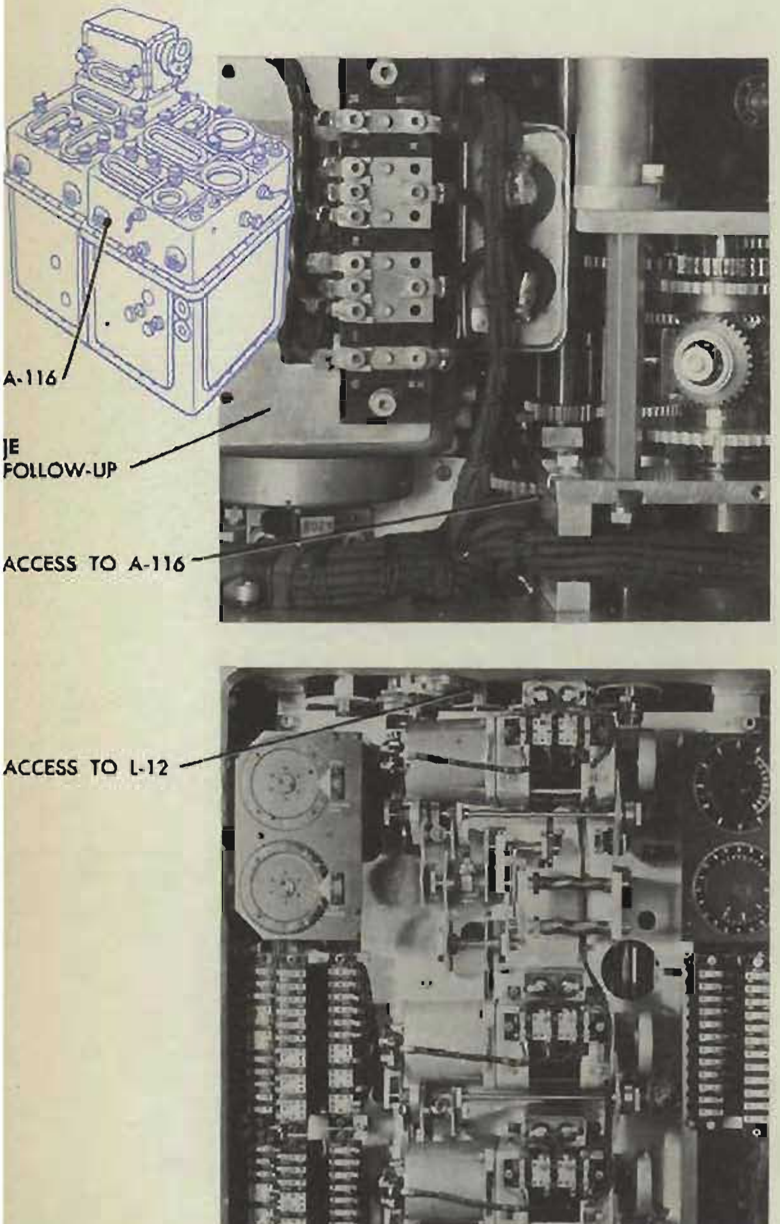
With *E* at 0°, adjust the small spur gear above the clamp until the input roller of the component integrator is positioned so that there is no motion of *jHc* when the *jdR* input line is turned.

The bevel gear must be at the *top* of the driving roller.

Tighten A-115, and recheck.



A-116 ELEVATION DIALS to L-12



Location

A-116 is under cover 1, at the left side, 3 inches in front of the damper on the *jE* follow-up. L-12 is under cover 7. The shaft is vertical, and only the upper limit is visible.

Check

Turn *E* from limit to limit.

The limit stop should function at −5° and +85° on instruments with Ser. Nos. 389 and lower, and at −25° and +85° on instruments with Ser. Nos. 390 and higher.

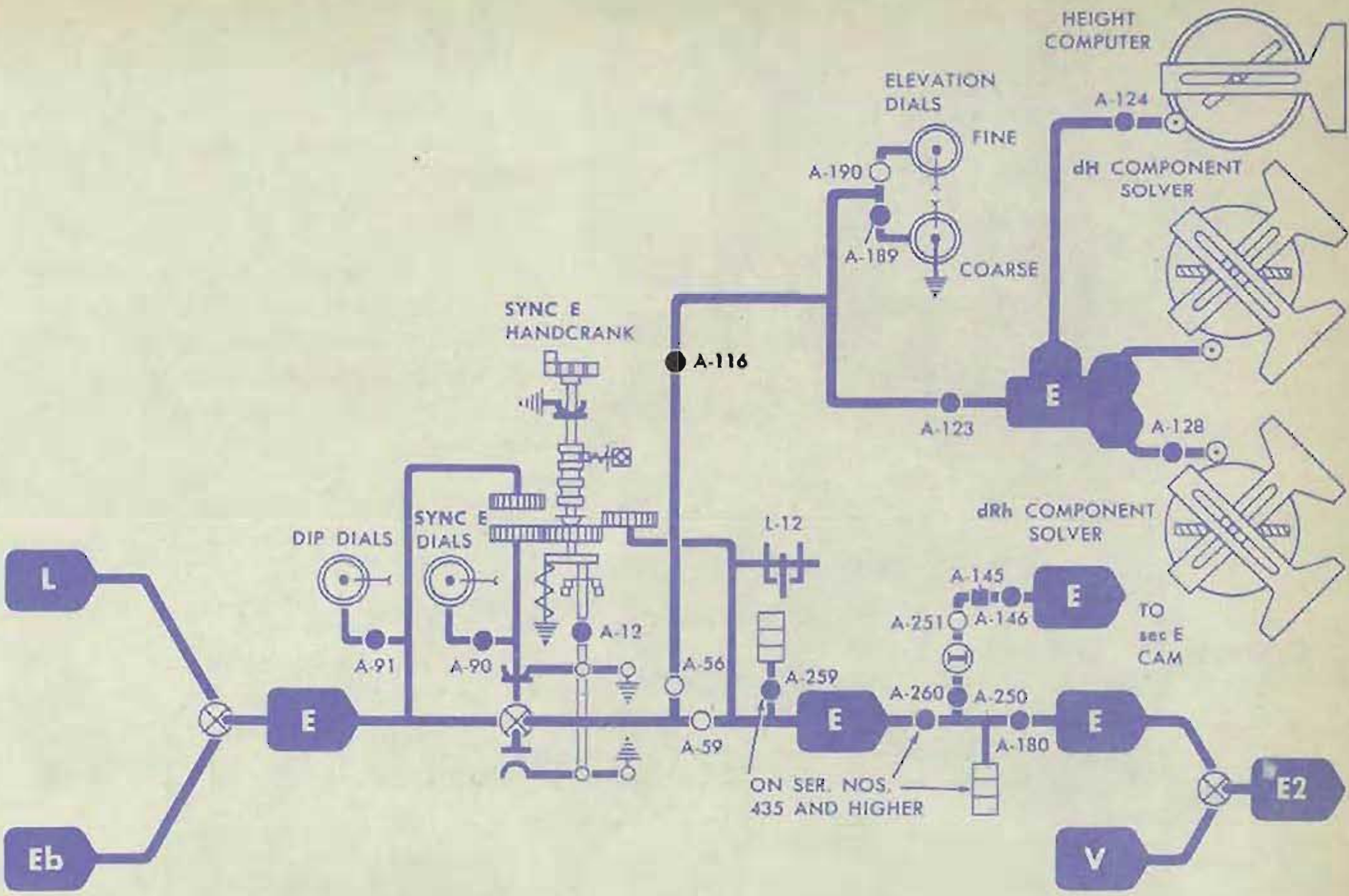
NOTE: If either limit cannot be reached, it is possible that A-123, A-124, A-128, A-180, or A-145 is causing a restriction; the restricting clamp should be loosened and readjusted later.

Adjustment

If the *E* dials do not read 85° when L-12 is at its upper limit, make A-116 slip-tight. Bring the *E* dials to 85° by turning the vertical shaft extending from A-116. Tighten A-116 and recheck at the lower limit.
Readjust any clamps loosened.
Check A-250, A-145, A-259, A-260, and A-180.

Note

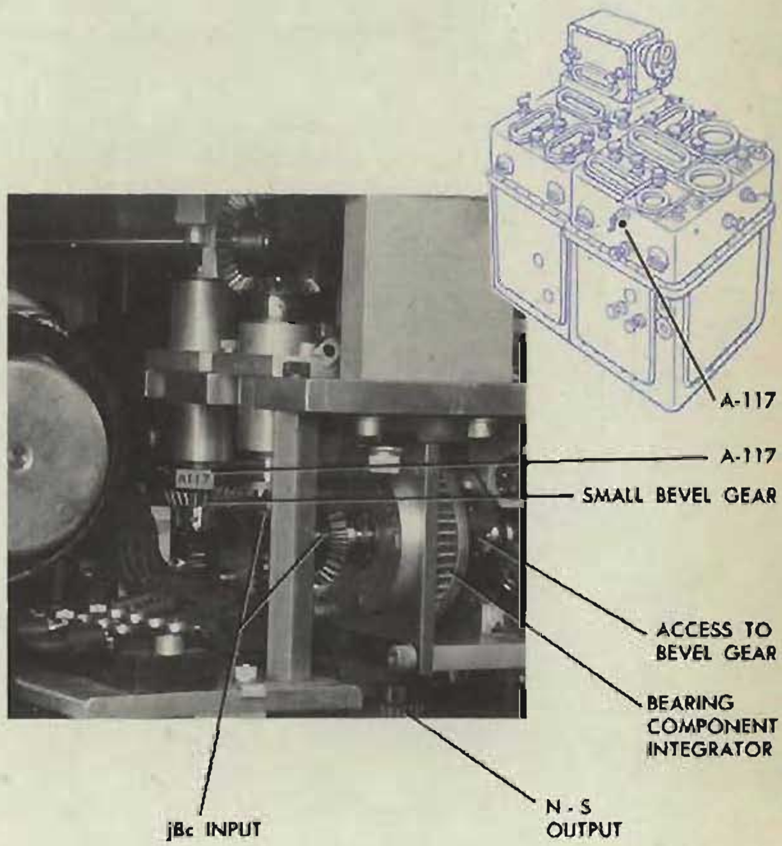
A-250 is omitted on instruments with Ser. Nos. 389 and lower. A-260 and A-259 are omitted on instruments with Ser. Nos. 434 and lower.



A-117 BEARING COMPONENT INTEGRATORS to B DIAL

Location

A-117 is under cover 1, at the center of the left side, to the rear of the bearing component integrator.

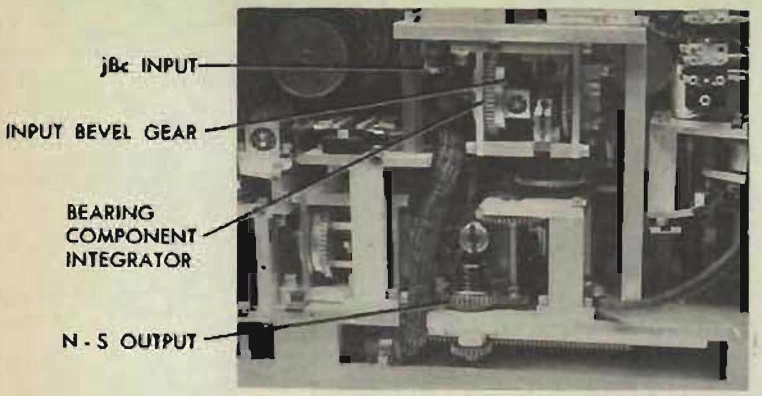


Check

Turn the power OFF.

Set the zero index of the compass ring dial against the fixed index. The *jBc* input bevel gear of the bearing component integrator should be at the right of the driving roller (viewed from the front of the instrument).

Turn the *jBc* input. Watch the spur gear directly below the bearing component integrator to see that there is no N-S output.

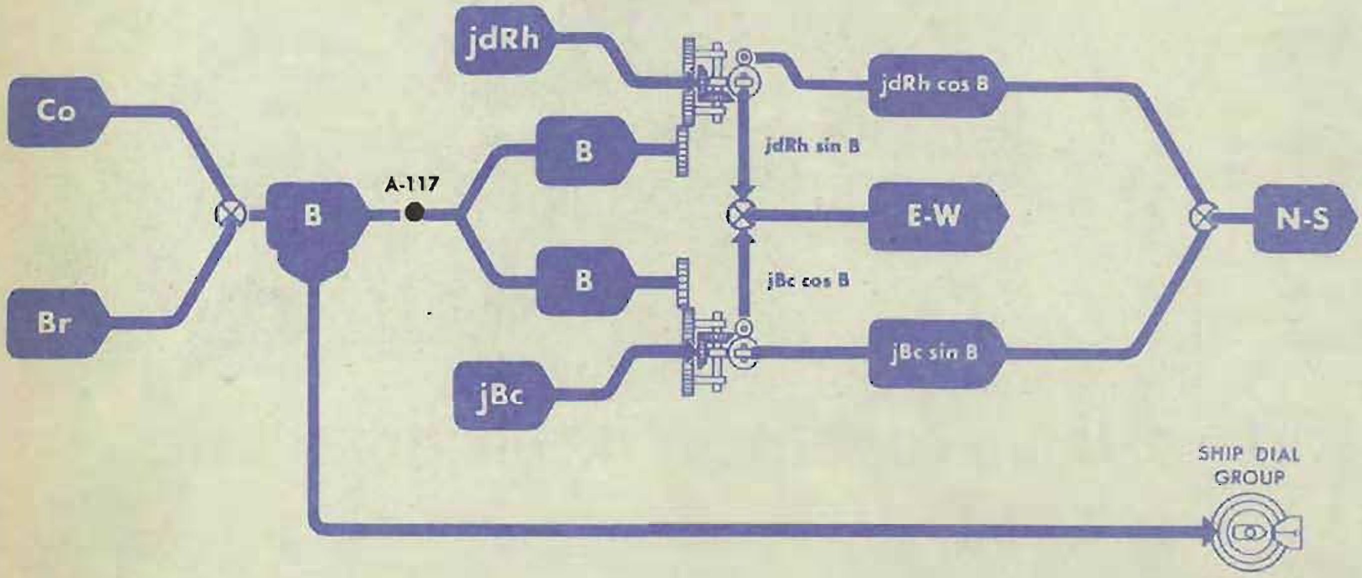


Adjustment

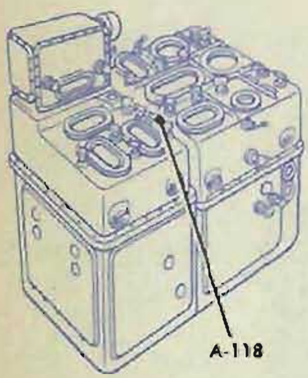
If the bevel gear is not at the right of the driving roller, or if there is any motion of the N-S output, make A-117 slip-tight.

Adjust the small bevel gear below A-117 until the angle gear is positioned so that there is no motion of the N-S output for any input of *jBc*. The bevel gear must be to the right of the driving roller.

Tighten A-117 and recheck.



A-118 SYNCHRONIZING THE RdE FOLLOW-UP



Location

A-118 is under cover 1, on the input gearing to the *RdE* follow-up.

L-7 is on the underside of the front top section. It can be seen from the cover 3 opening. The shaft is horizontal,with the upper limit to the rear.

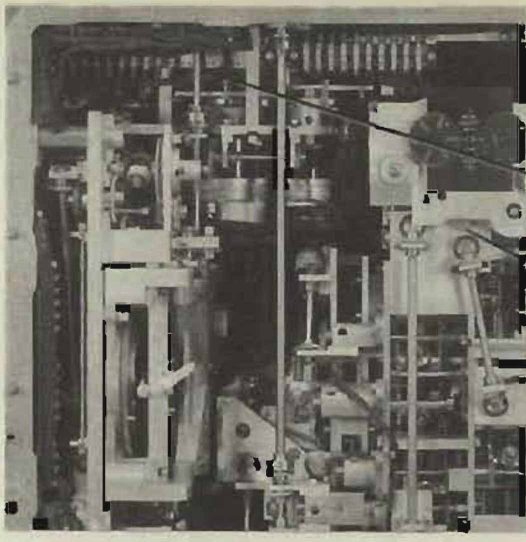
CAUTION

With the power OFF, turn the *RdE* follow-up manually between limits. If there is any restriction before the limits are reached, A-108, A-134, or A-154 is upset. Determine which adjustment is causing the restriction and loosen the clamp.

Check

Turn the power ON.

Set *Br* at 90°.
Set *E* at 60°.
Set *So* at 0 knots and *Sh* at 400 knots.
Set *A* at 180°.
Turn *dH* in a decreasing direction until *RdE* reaches the lower limit of L-7. *dH* should read between −107 and −110 knots, and the *RdE* follow-up should be synchronized.

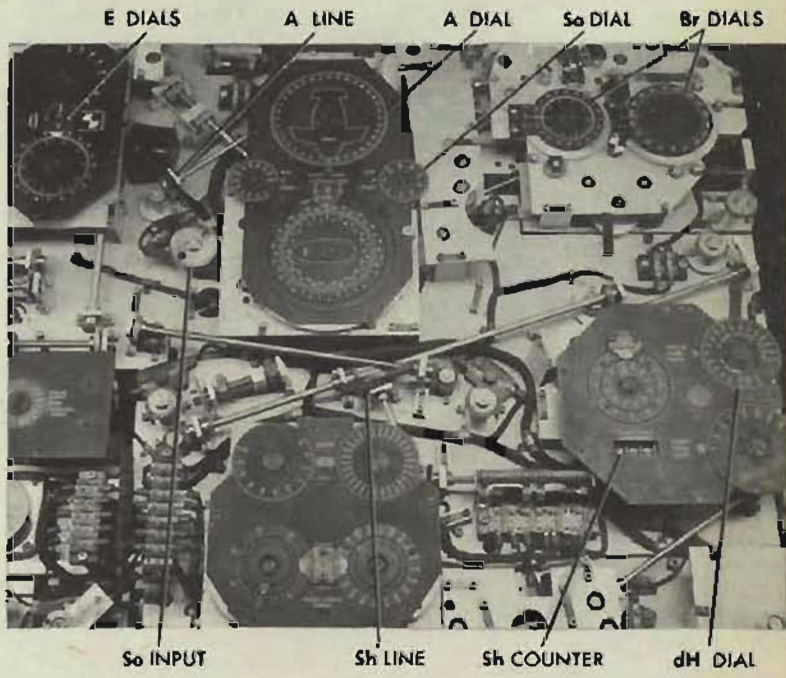


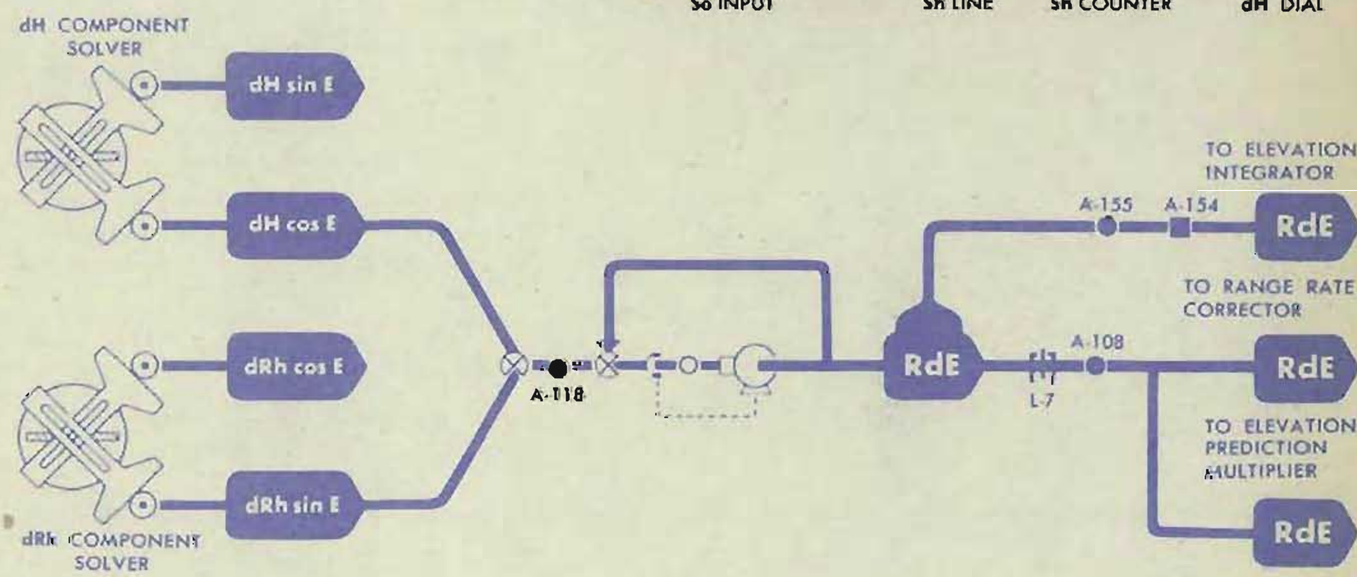
Adjustment

If *dH* does not read correctly when *RdE* is at the lower limit, slip-tighten A-118. Hold *dH* at −108 knots and turn the spur gear above A-118 until the follow-up synchronizes at the lower limit of L-7.

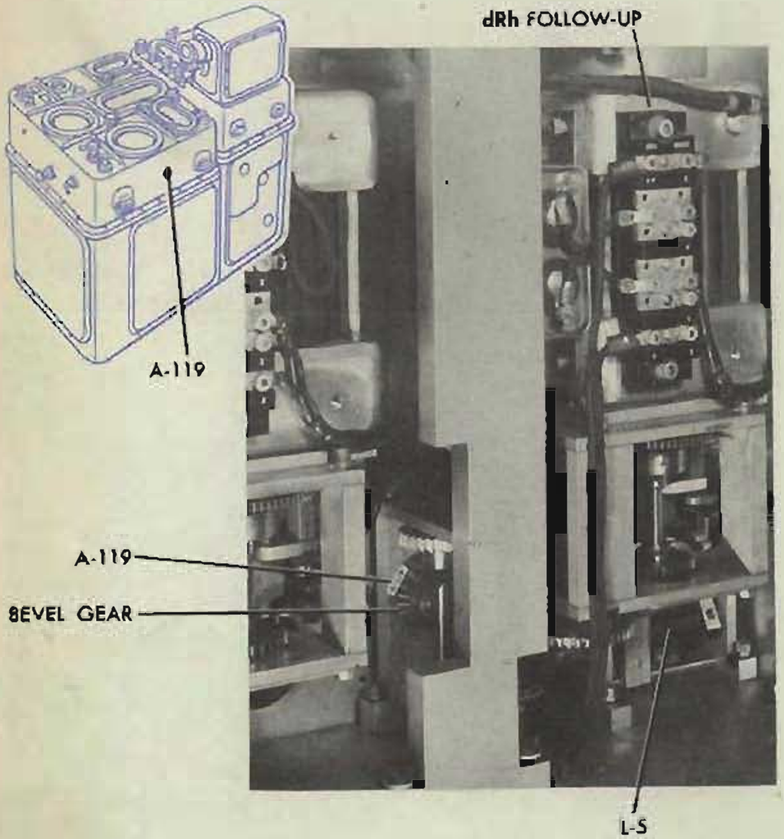
Tighten A-118 and recheck at the upper limit. To check the upper limit, set *A* at 0° and increase *dH* until the upper limit of L-7 is reached. *dH* should read between +107 and +110 knots.

Remove all wedges.
Readjust any clamps loosened, and check A-108, A-154, and A-134.
Recheck by running elevation B tests.





A-119 SYNCHRONIZING THE dRh FOLLOW-UP



Location

A-119 is under cover 1, on the *dRh* follow-up input gearing.

L-5 is below the *dRh* follow-up. Its lower limit is toward the rear.

CAUTION

Turn the *dRh* output from limit to limit manually before turning on the power, to make sure both limits can be reached. If they cannot be reached, loosen A-125.

Check

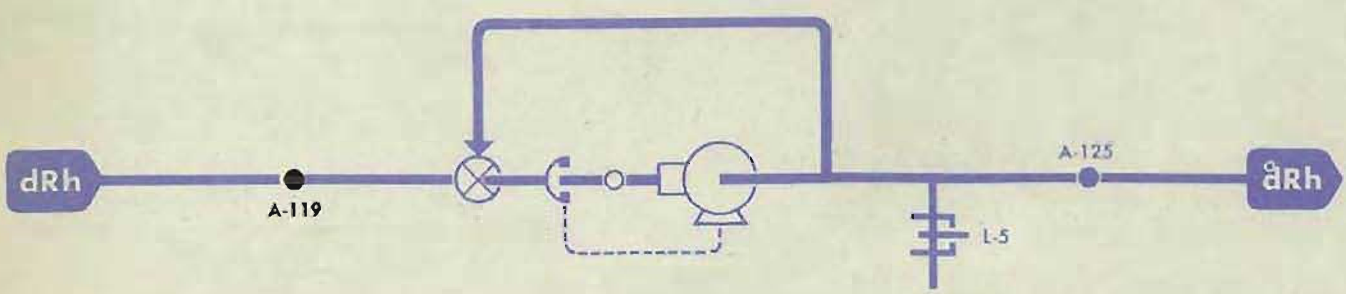
Remove the KRR lead on the target angle push-button switch.

Turn the power ON.

Set *Br* and *A* at 0° and wedge the lines.
Set *Sh* at 400 knots and wedge the line.
Set *So* at 0 knots.

Increase *So* to 40 knots. The *dRh* follow-up should be synchronized at the lower limit of the stop just as *So* reaches 40 knots.

Turn *Br* and *A* to 180° and wedge the lines.
Increase *So* to 40 knots. The *dRh* follow-up should be synchronized at the upper limit of the stop just as *So* reaches 40 knots.



Adjustment

If the follow-up is not synchronized at the proper positions, slip-tighten A-119.

Check that *A* and *Br* are at 180°, and *So* is at 40 knots.

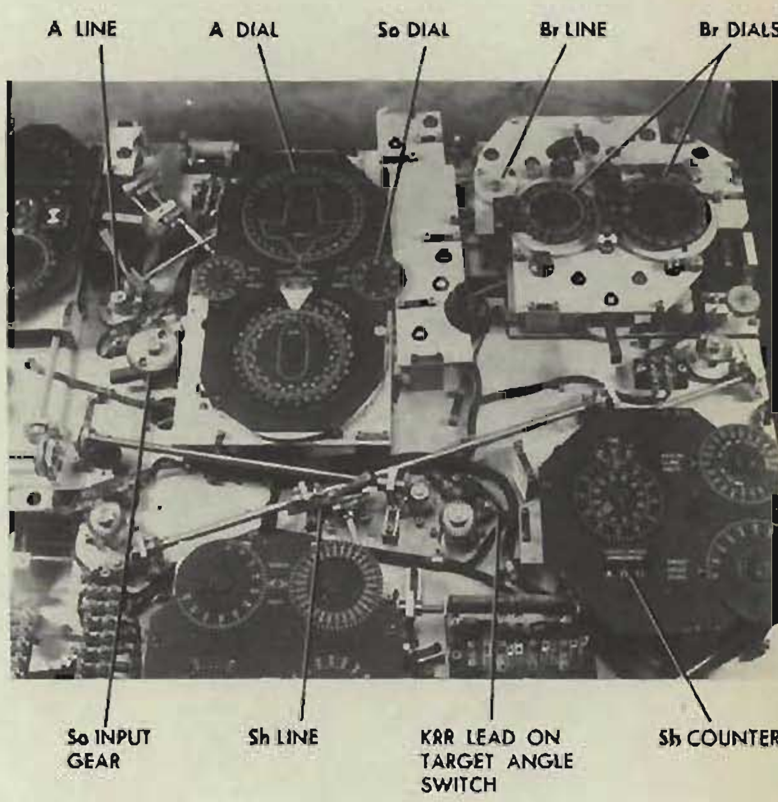
Turn the bevel gear on which A-119 is located until the follow-up synchronizes at the upper limit of the stop.

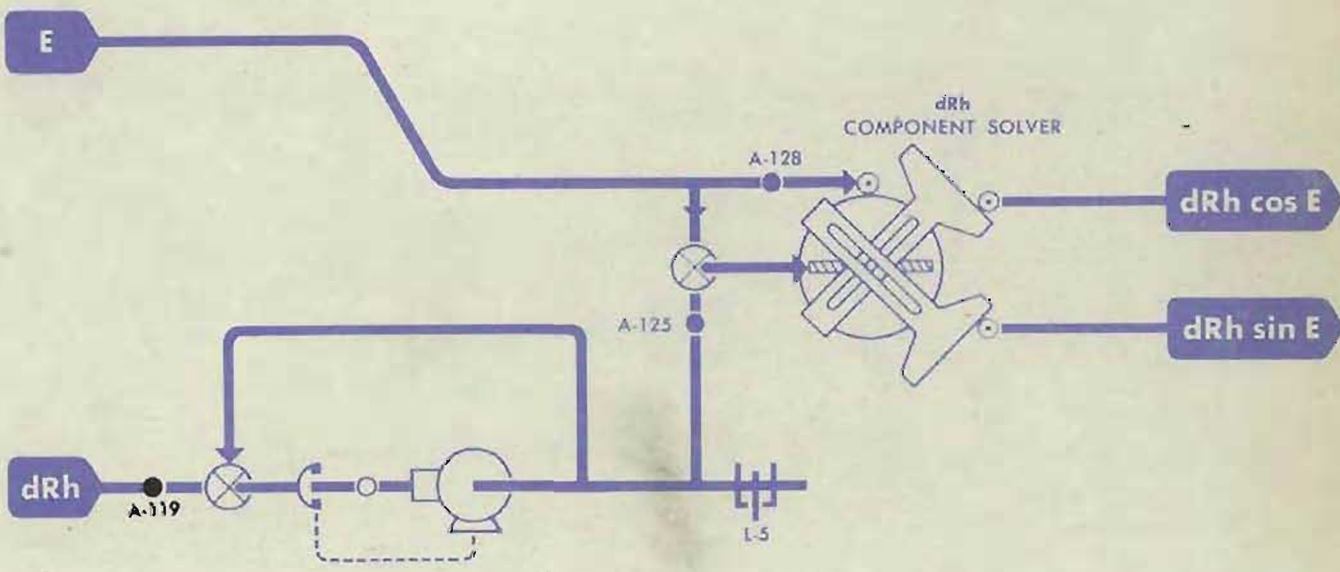
Tighten A-119. Set *Br* and *A* at 0°. Increase *So* to 40 knots and check to see that the follow-up is synchronized at the lower limit.

Split any overtravel.

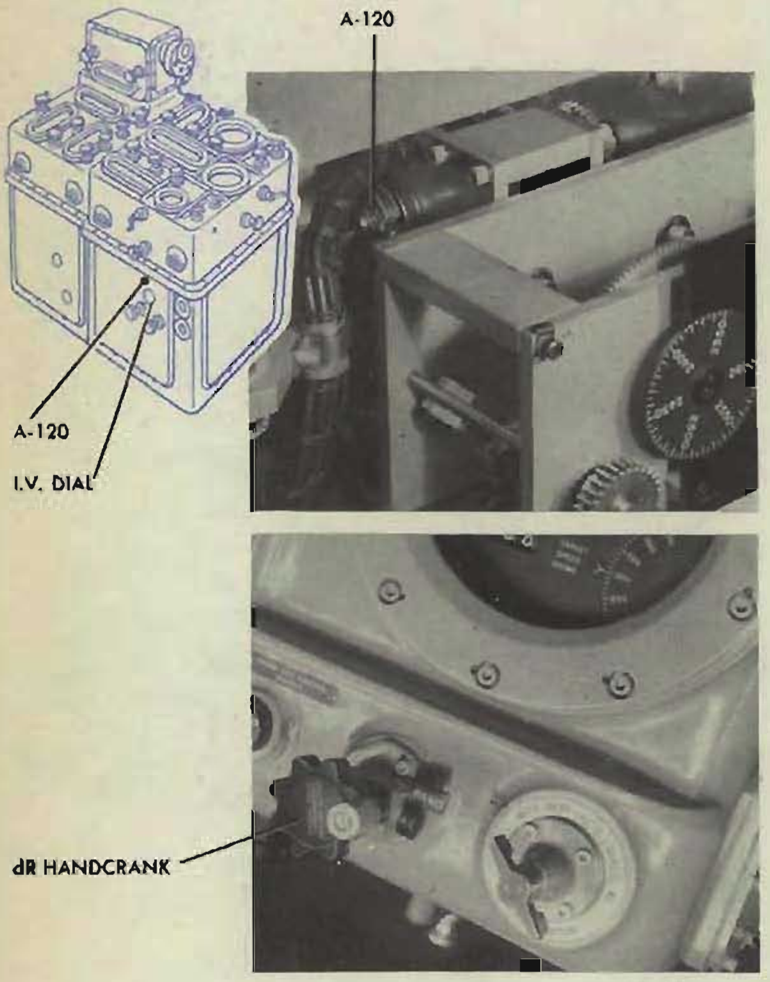
Check A-125.

Remove all wedges and replace the KRR lead.





A-120 I.V. HOLDING FRICTION



Location

A-120 is under cover 3, behind the *I.V.* dial.

Check

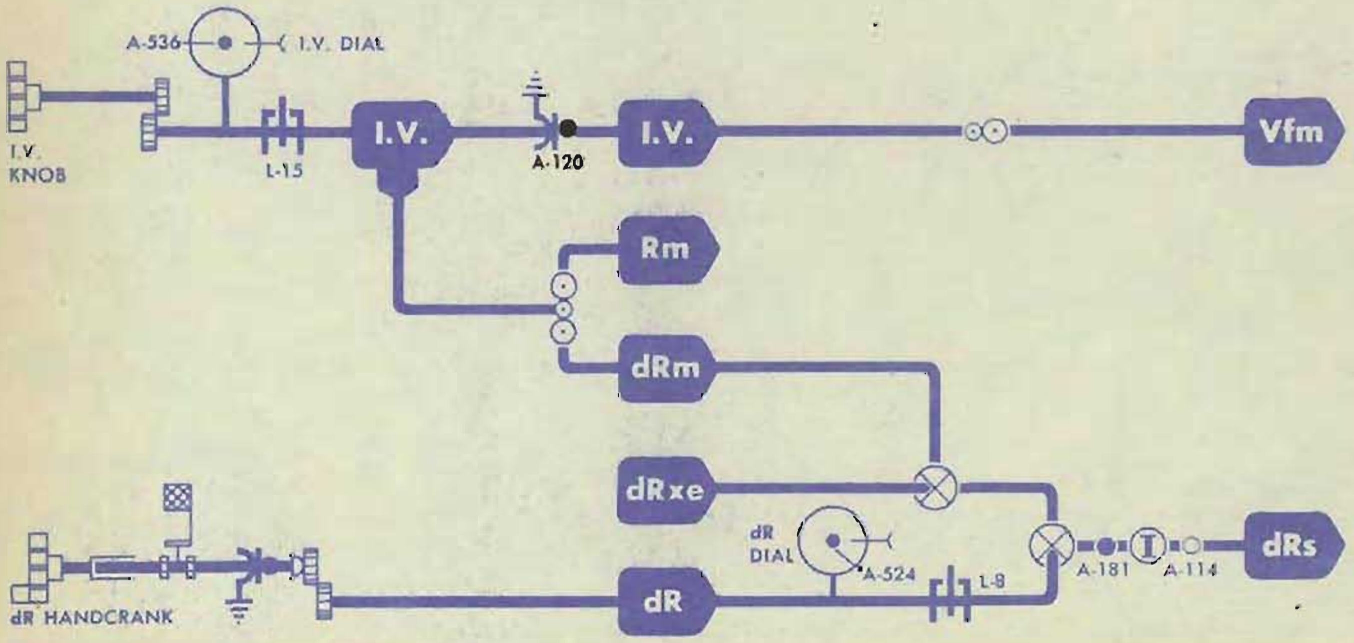
This friction should hold the *I.V.* setting without too much drag on the line.

Check the friction setting by turning *dR*.

Adjustment

If any motion backs through the *I.V.* input gear, loosen A-120 and turn it until there is sufficient friction to hold the *I.V.* setting.

Tighten A-120 and recheck.

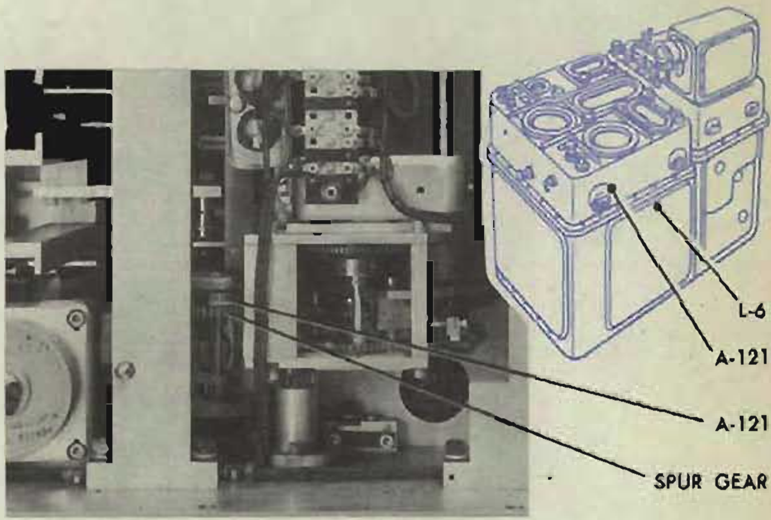


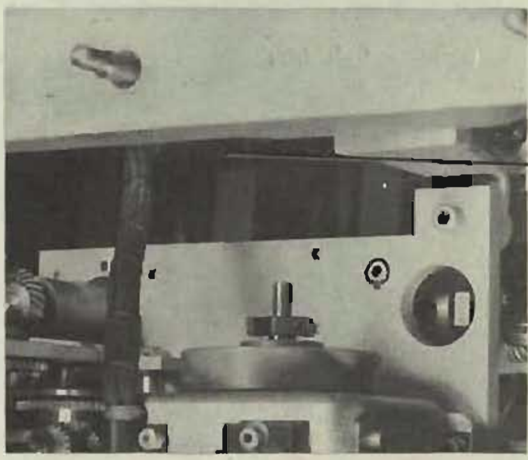
A-121 SYNCHRONIZING THE RdBs FOLLOW-UP

Location

A-121 is under cover 1, in front of the *RdBs* follow-up.

L-6 is under cover 5, above the *Dtwj* follow-up. Its upper limit is toward the center of the instrument.





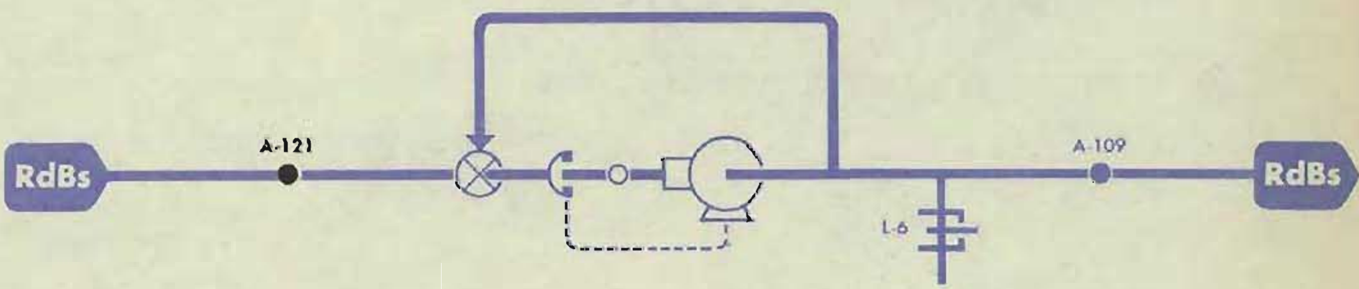
Check

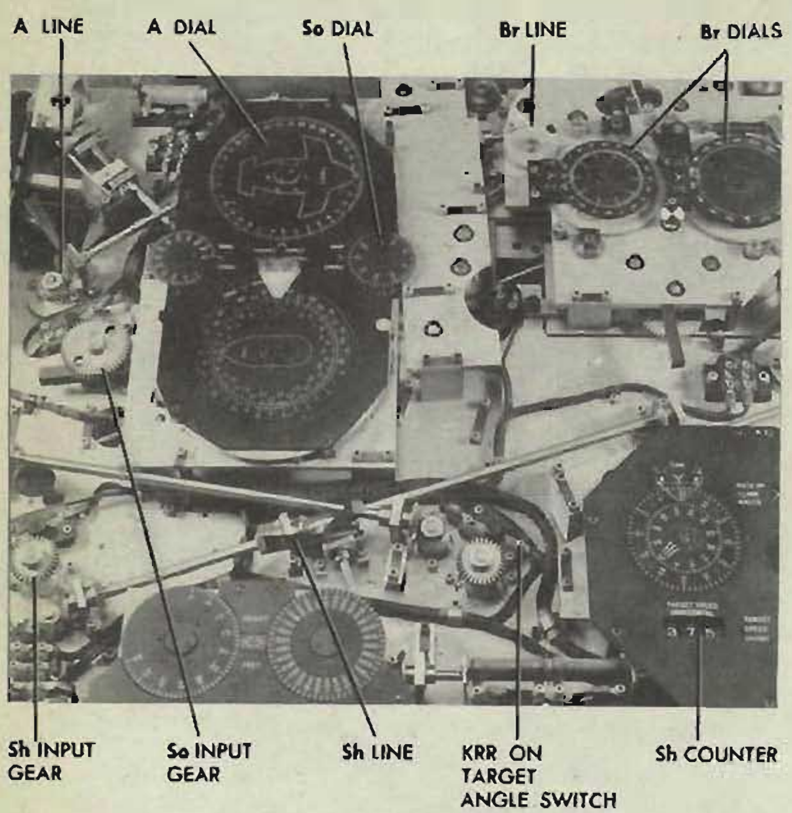
CAUTION: Turn the power OFF. Turn the *RdBs* follow-up output between limits manually to make sure there is no restriction within the limits of the stop. If either limit cannot be reached, loosen A-109.

Turn the power ON.

Remove the KRR lead on the target angle push-button switch. Set *Br* at 90° and wedge the line.
Set *A* at 90°, and *Sh* at 375 knots and wedge the lines.

Increase *So* to 25 knots. The *RdBs* follow-up should be synchronized at the upper end of the limit stop just as *So* reaches 25 knots on the dial.





Set *A* and *Br* at 270°. Increase *So* to 25 knots. The *RdBs* follow-up should be synchronized at the lower end of the limit stop as *So* reaches 25 knots. Any overtravel should be split.

Adjustment

If the follow-up does not synchronize at the proper *So* value, slip-tighten A-121.

Set *A* and *Br* at 90°, and *So* at 25 knots.

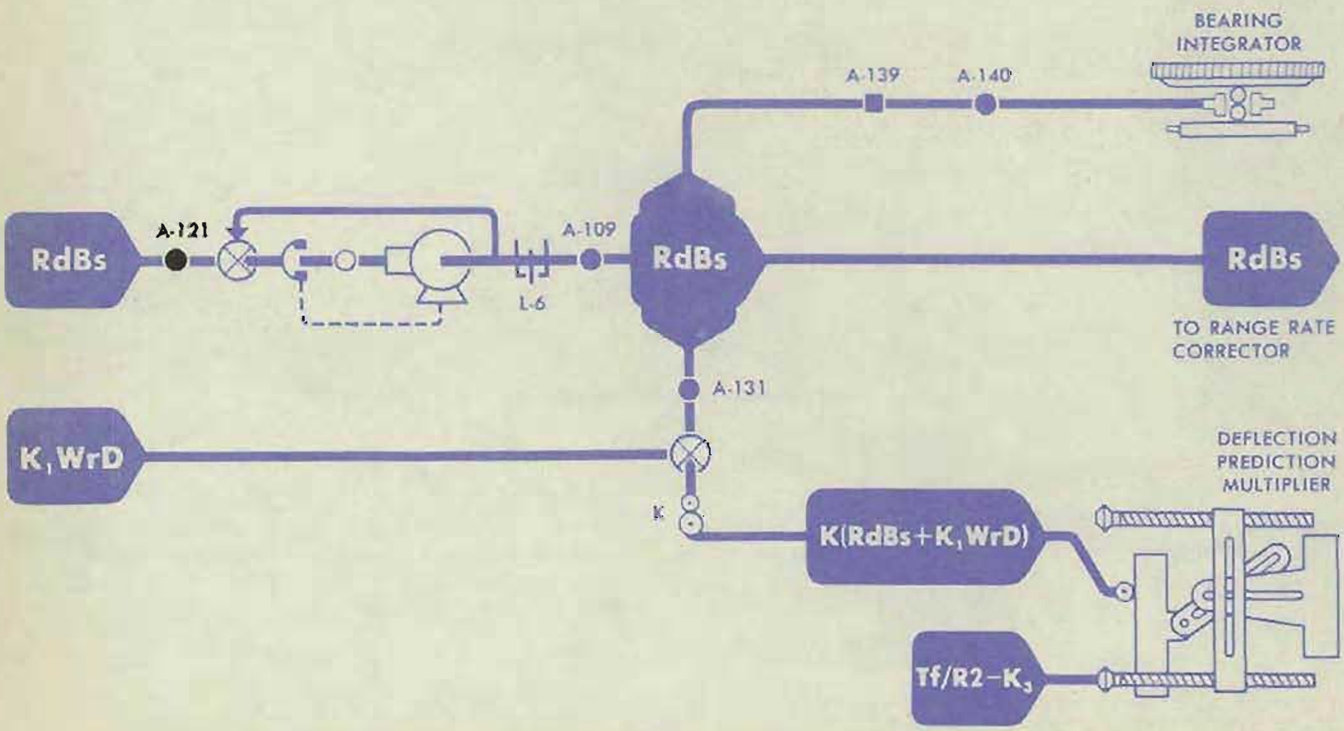
Turn the spur gear below A-121 until the follow-up is synchronized at the upper limit.

Tighten A-121. Set *Br* and *A* at 270° and recheck to see that the follow-up is synchronized at the lower limit.

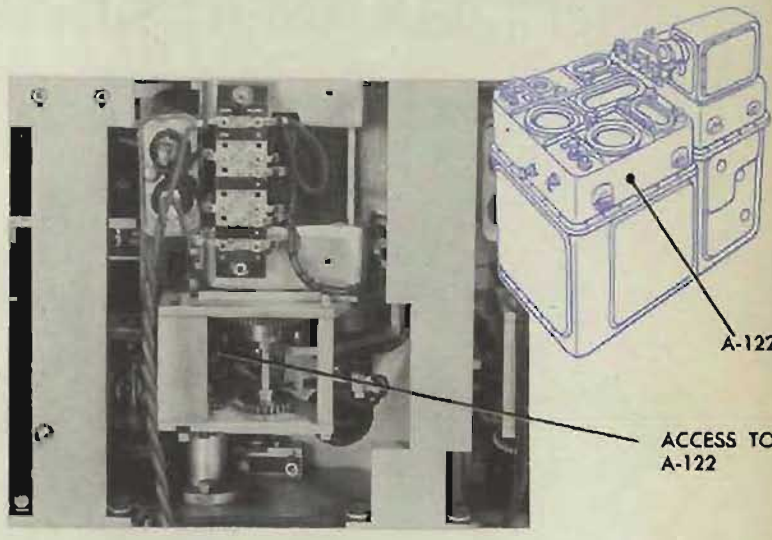
Split any overtravel.

Remove all wedges and replace the KRR lead.

Check A-109, and run the bearing B tests.



A-122 So HOLDING FRICTION



Location

A-122 is located under cover 1, behind the *RdBs* follow-up.

Check

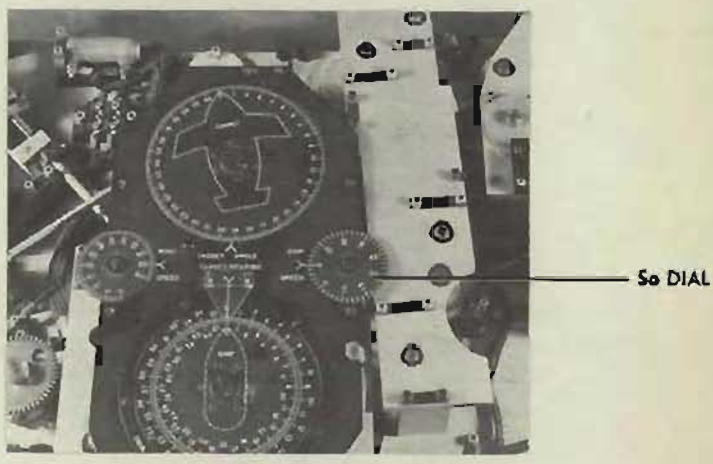
This friction should hold the *So* setting without too much drag on the line.

Set *So* at 40 knots.

Turn the power ON.

Turn *Br* through 90°.

No motion of *Br* should back through the *So* line to turn the *So* dial.

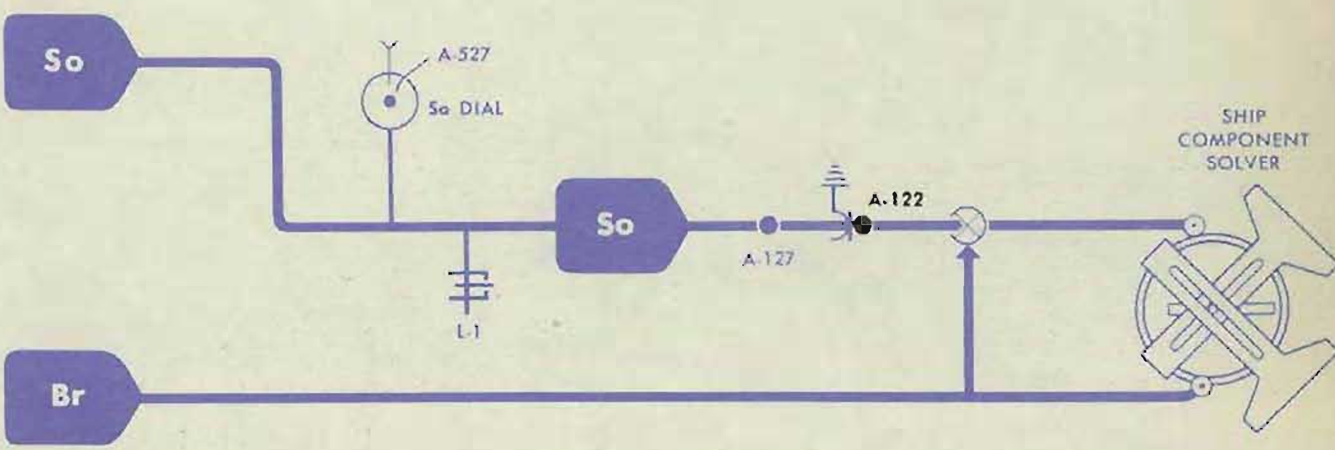


Adjustment

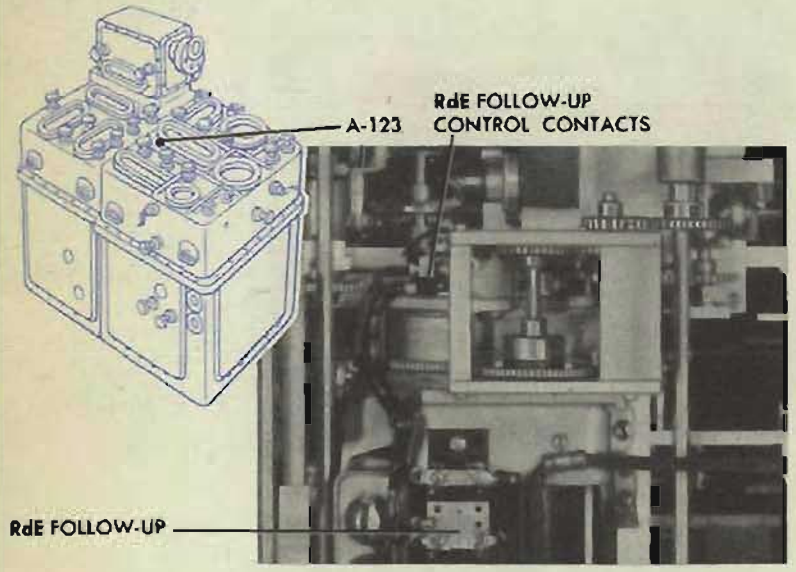
Turn the power OFF.
If any motion backs through *So*, loosen A-122.
Turn the clamp clockwise to increase the friction.

Tighten A-122, and recheck.

NOTE: If the *So* holding friction is adjusted excessively tight, the *So* receiver motor will not function. To check for this condition, make the synchronizing test of the *So* receiver. See page 62.



A-123 dH COMPONENT SOLVER to E DIALS



Location

A-123 is under cover 1, to the right of the *RdE* follow-up contacts. It is the upper clamp on a short vertical shaft.

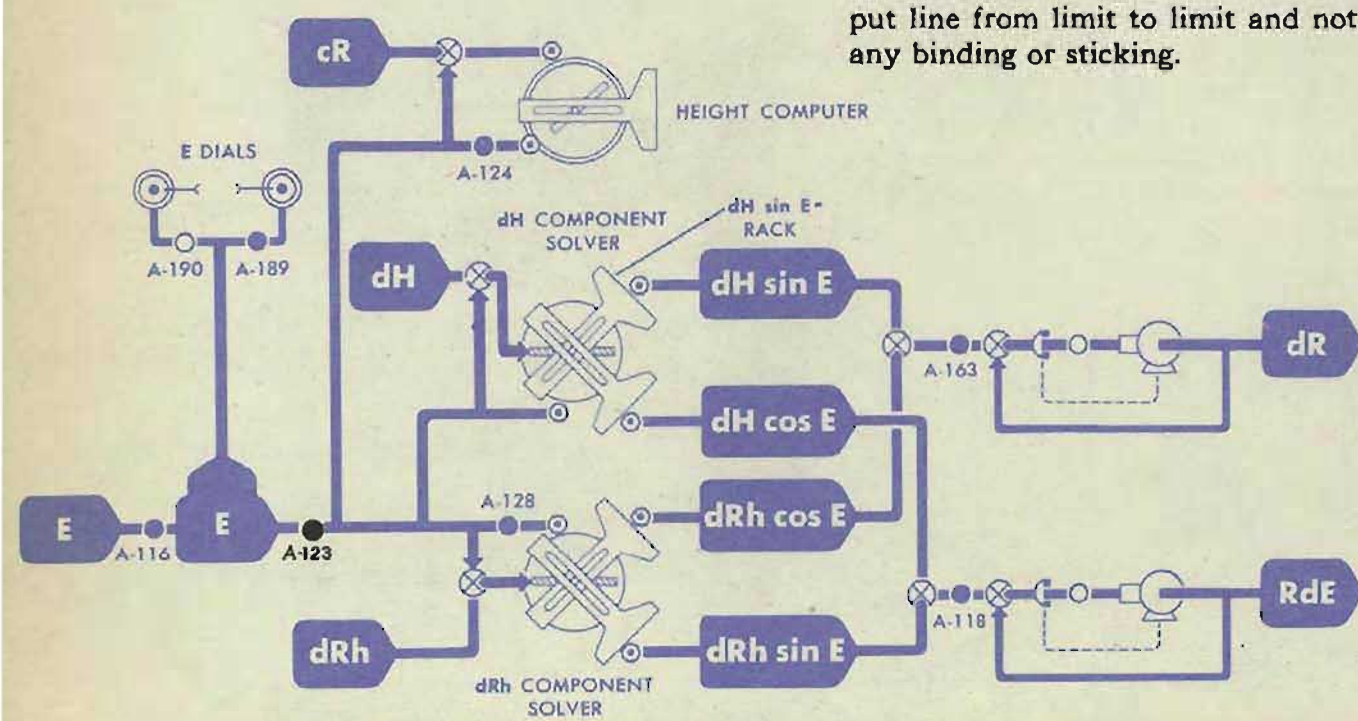
Note

A-123 can be reached with a long screw driver through the back top section.

Possible damage

If A-123 is upset, the *dH* component solver vector gear may have been run beyond its limit with such force that the hangers, gears, and shafts of the lead screw input line may have been damaged.

To check for damage, turn the *dH* input line from limit to limit and note any binding or sticking.



Check

Set *E* at 0°.
The spur gear on the lead screw of the *dH* component solver vector gear should be toward the front. The *dH* component solver is the fourth solver from the top, and can be seen through the access at the front of the *RdBs* follow-up.

Set *dH* at 0 knots.
Set up a dial indicator on the *dH* sin *E* rack.
Run *dH* from 0 knots to DIVE 250.

The output rack movement should not exceed 0.002 inch on the indicator. Make sure that *E* is at 0°.

Adjustment

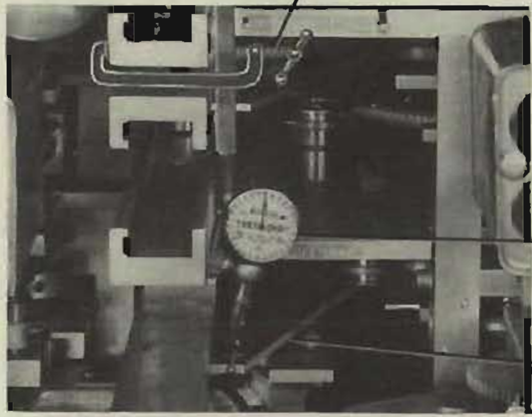
If the indicator shows more than 0.002-inch motion, slip-tighten A-123.

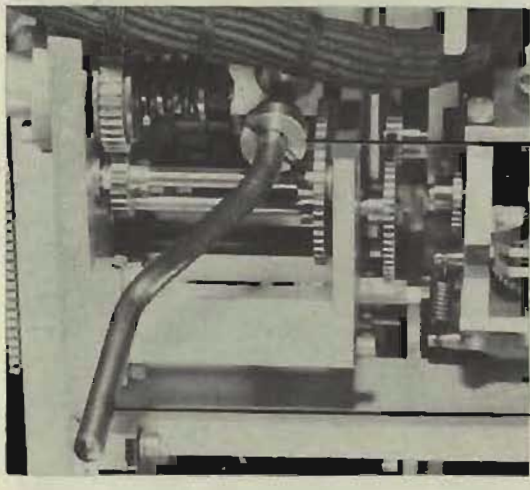
Correct all the way by turning the *dH* vector gear with a gear pusher.

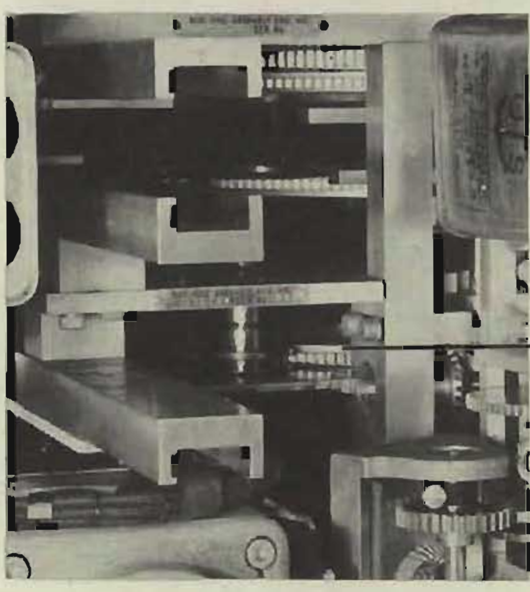
Tighten A-123 and recheck, by running *dH* from DIVE 250 to CLIMB 150.

Remove the indicator.

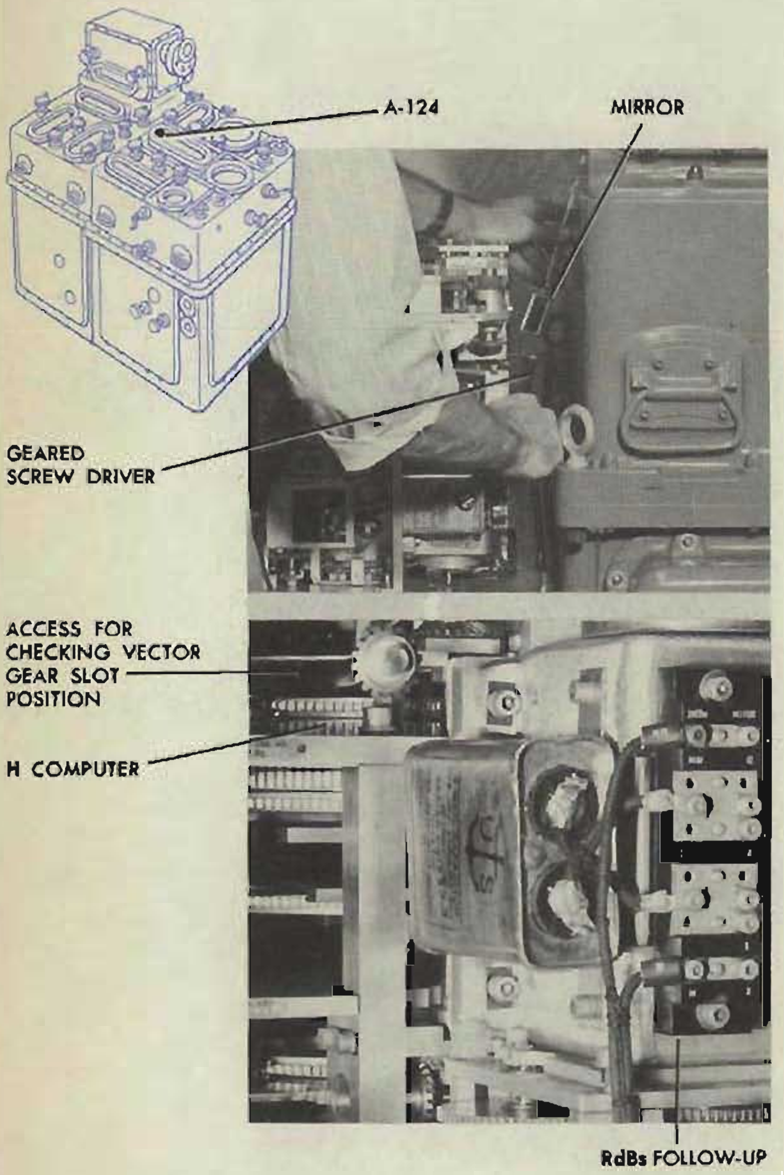
Check A-124, A-128, A-118, A-163.







A-124 HEIGHT COMPUTER to E DIALS



Location

A-124 is under cover 1, to the right of the *RdE* follow-up contacts.

Note

A-124 can be reached with a geared screw driver.

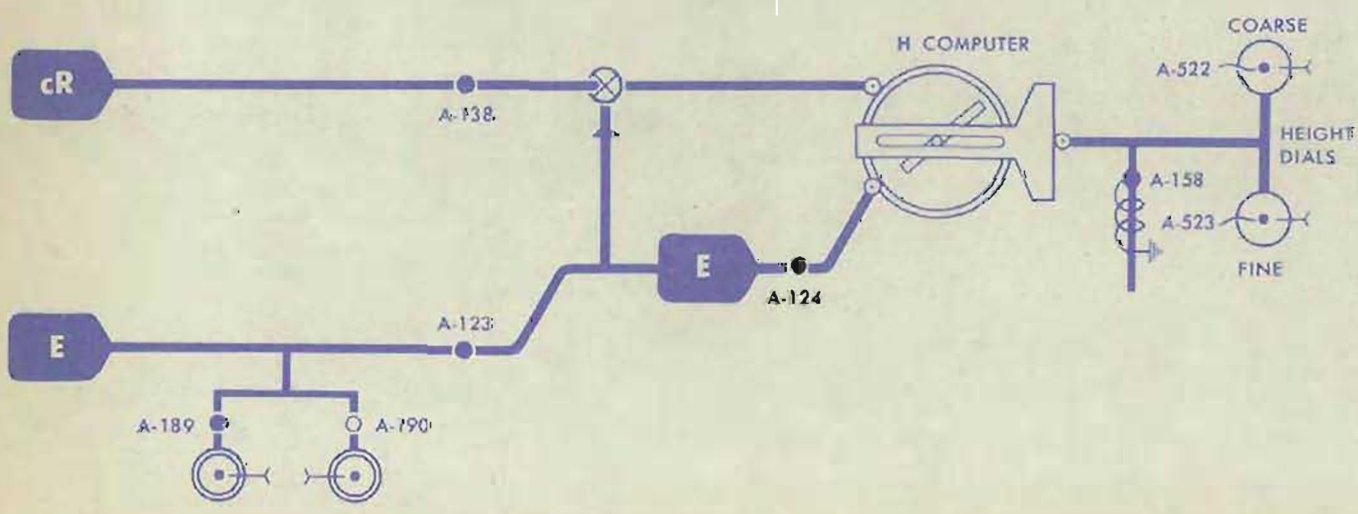
Check

Set *E* at 0°.
The *H* computer vector gear slot should be at the front. The slot can be seen through the access at the right of the front top section. The *H* computer is the top unit of the solver group.

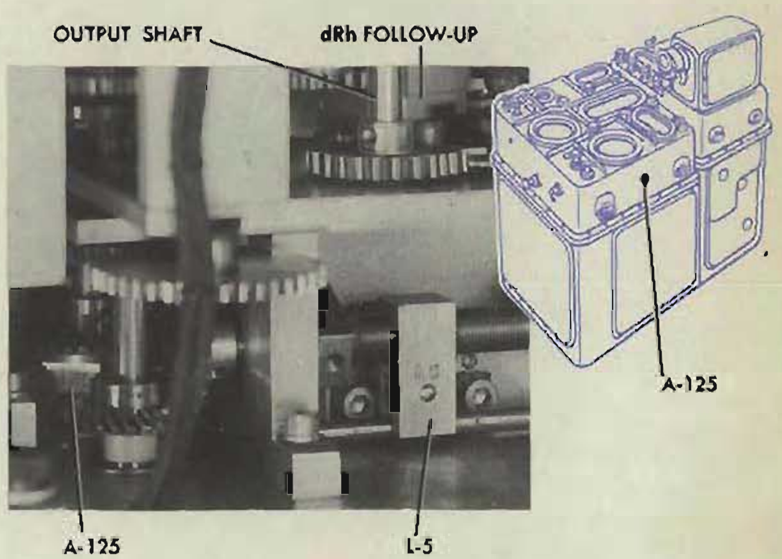
Use the *H* dial as an indicator. Turn *cR* from 0 to its upper limit. The *H* dials should not move.

Adjustment

If the dials move, slip-tighten A-124. Use a gear pusher to move the vector gear to a position at which full travel of *cR* causes no motion on the *H* dials.
Tighten A-124, and recheck.
Check A-522 and A-523.
Readjust A-138.



A-125 dRh COMPONENT SOLVER to dRh LINE



Location

A-125 is under cover 1, below the *dRh* follow-up, to the front of limit stop L-5.

Possible damage

If A-125 is upset, the traveling nut of the *dRh* component solver may have jammed at one end of the lead screw in the vector gear. Turn the output shaft of the *dRh* follow-up to move the lead screw. Note any binding or sticking.

Check

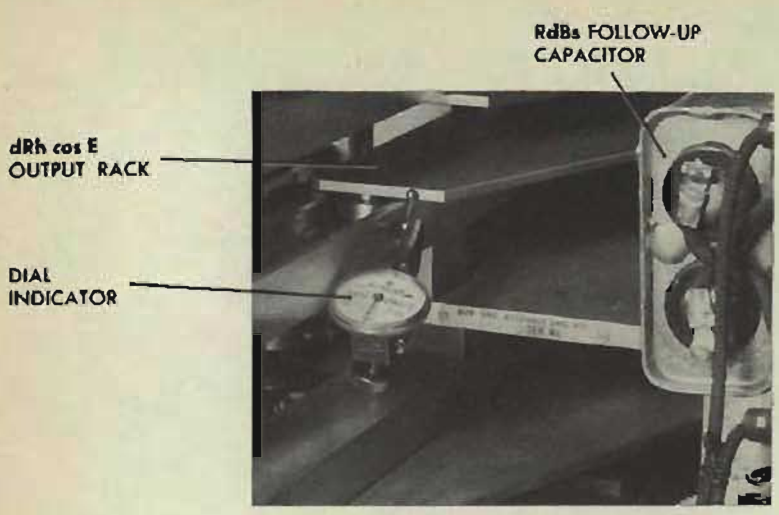
Remove the KRR lead from the target angle switch.

Turn the power ON.

Set *A* at 90°, *Br* at 90°, *So* and *Sh* at 0 knots, and wedge the lines.
Set *E* at 85°.

The *dRh* component solver is the third solver from the top. It can be seen through the access hole on the right side of the front top section in front of the *RdBs* follow-up. Set up a dial indicator against the *dRh* cos *E* output rack.

Turn *E* from 85° to 0°.
The *dRh* cos *E* rack should not move more than 0.002 inch, as read on the indicator dial.



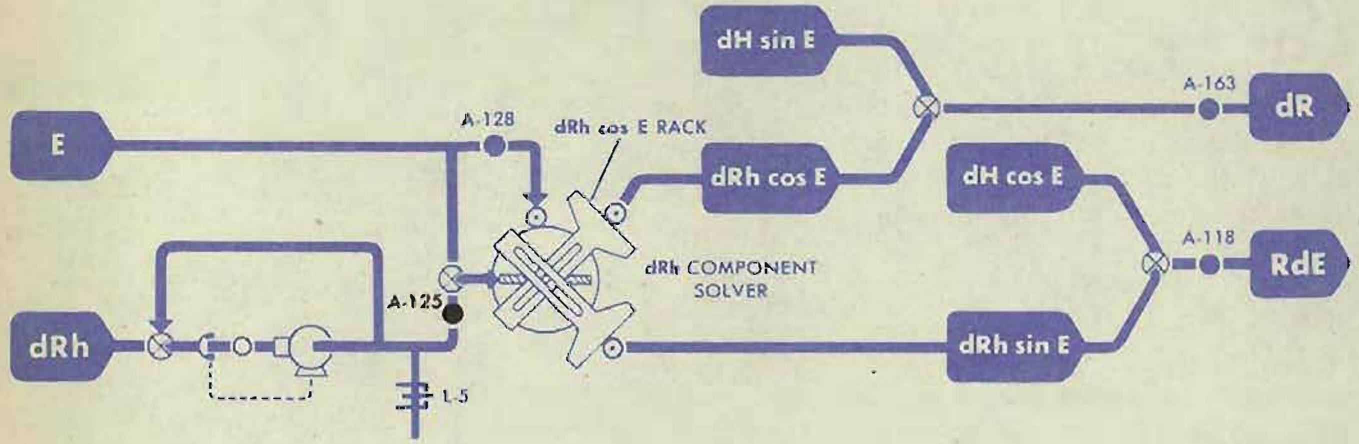
Adjustment

If the indicator moves more than 0.002 inch, slip-tighten A-125.

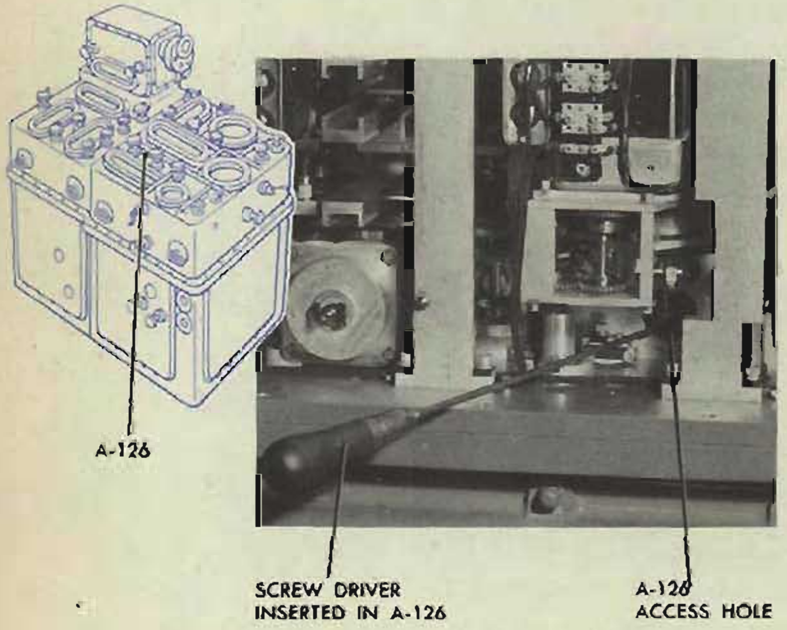
Correct all the way by turning the bevel gear on which A-125 is located. Tighten A-125 and recheck.

Readjust until the indicator movement is less than 0.002 inch. Remove all wedges.

Replace the KRR lead. Check A-118 and A-163.



A-126 dH COMPONENT SOLVER to dH DIAL



Location

A-126 is under cover 1.

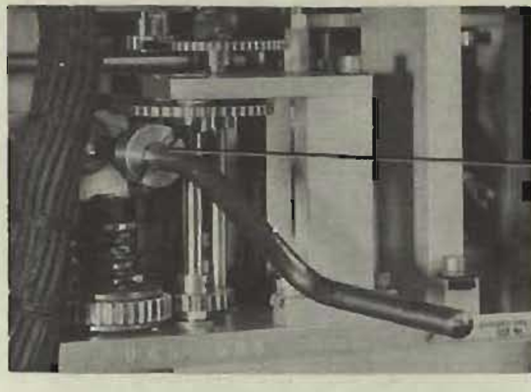
It can be seen near the base plate of the control unit at the center rear just above a spur gear. It is accessible through a hole below the *RdBs* follow-up.

Possible damage

If A-126 is loose or upset, the lead screw of the *dH* component solver may be jammed at the end of its travel. Turn the *dH* line through its full travel. Note any sticking or binding.

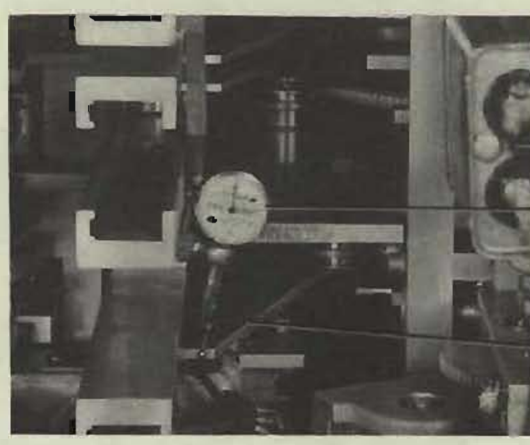
Check

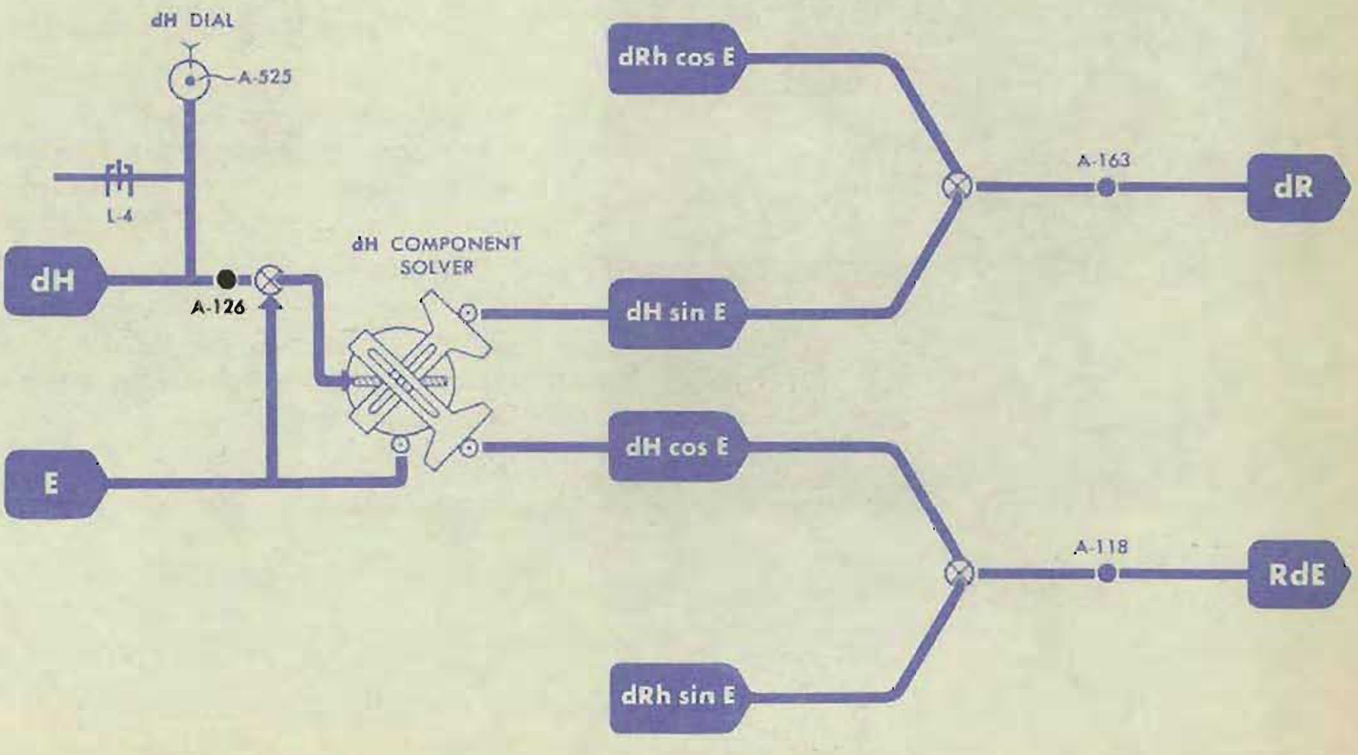
Set *dH* at 0 knots.
Set *E* at 0°.
Set up a dial indicator against the *dH* sin *E* output rack.
The *dH* component solver is the fourth component solver from the top in the solver group. It can be seen by looking through the access in front of the *RdBs* follow-up.
Turn *E* from 0° to 85°.
The indicator should register no more than 0.002-inch movement of the rack.



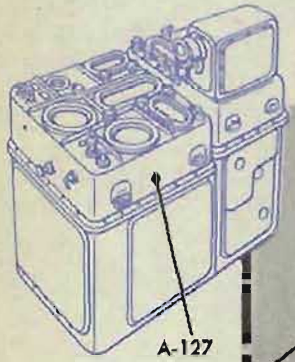
Adjustment

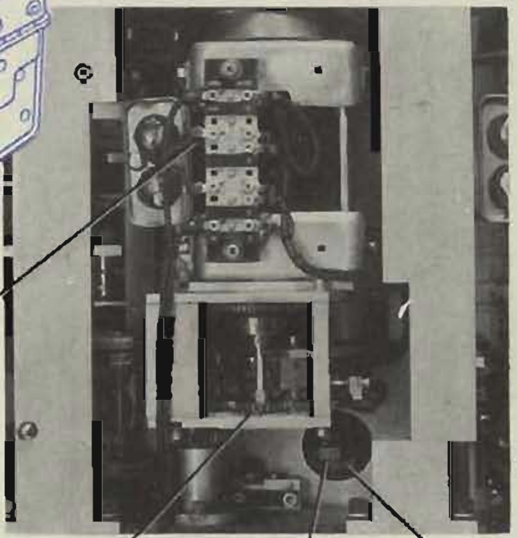
If the indicator shows more than 0.002-inch motion, slip-tighten A-126. Use a gear pusher and correct all the way by turning the spur gear immediately below A-126. The *dH* dial must not move off the zero position.
Tighten A-126, and recheck.
Remove the dial indicator.
Check A-118 and A-163.





A-127 SHIP COMPONENT SOLVER to So DIAL



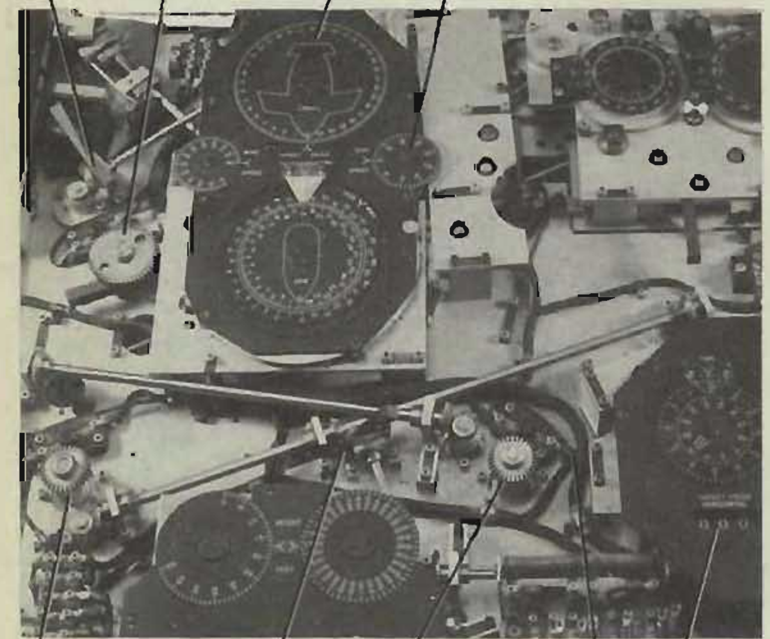


Location

A-127 is under cover 1, below the *RdBs* follow-up.

Possible damage

If A-127 is upset, the cam-follower pin or the cam groove of the ship component solver may be damaged. Check for obstructions by running *So* between its limits.



Check

Turn the power ON.

Set the *So* dial at 0 knots and wedge the *So* input gear.
Set *A* and *Sh* at 0 and wedge the lines.
Set *Br* at 90°.

NOTE: Disconnect lead KRR from the target angle push-button switch to prevent the *A* and *Sh* follow-ups from driving these quantities off their zero settings.

The target component solver outputs are now at zero, and the *RdBs* follow-up will indicate only the output of the ship component solver.

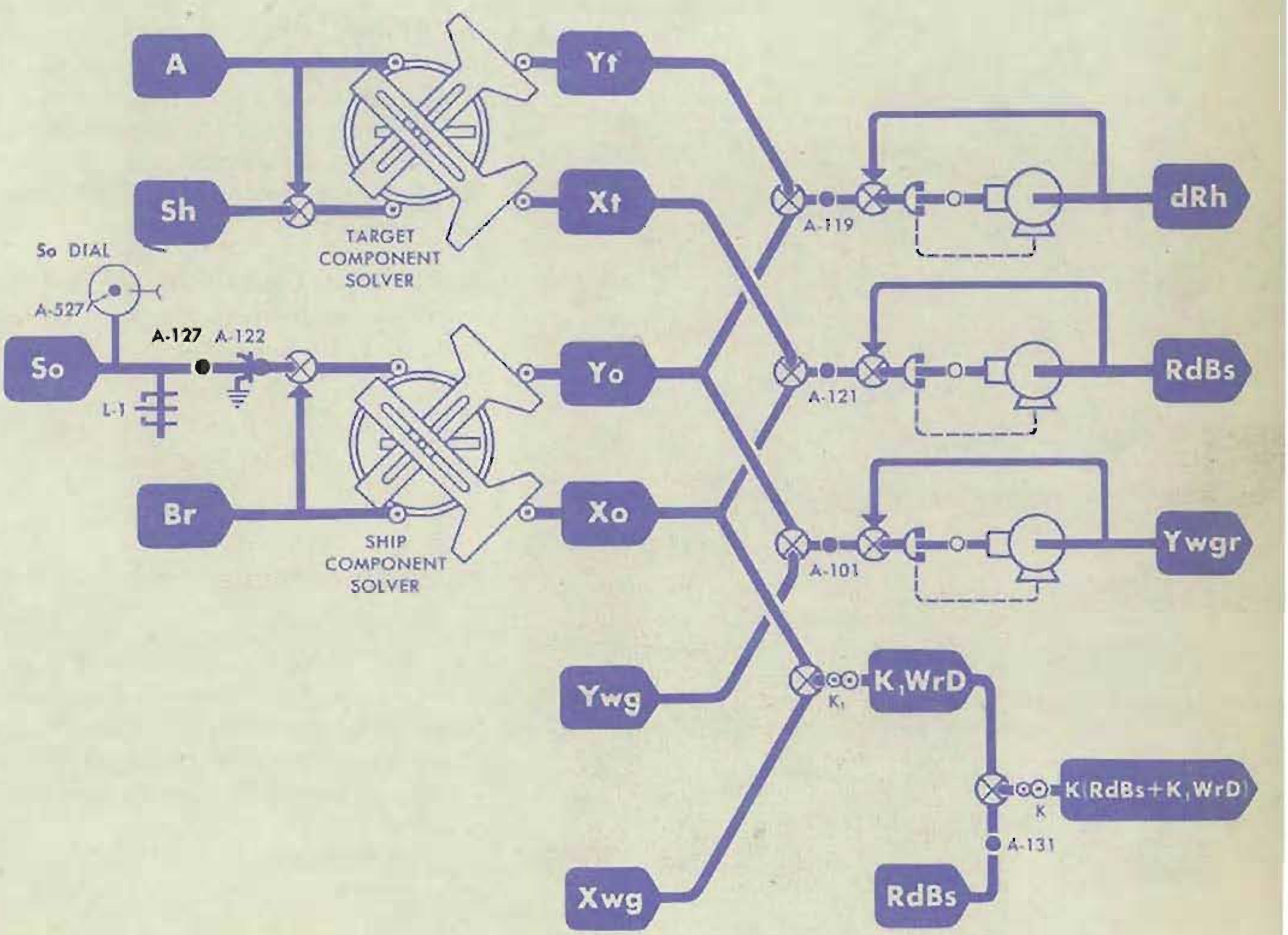
Mark the *RdBs* follow-up output gear for use as an indicator. Turn *Br* from 90° to 270°. The follow-up indicator marks should remain matched.

Adjustment

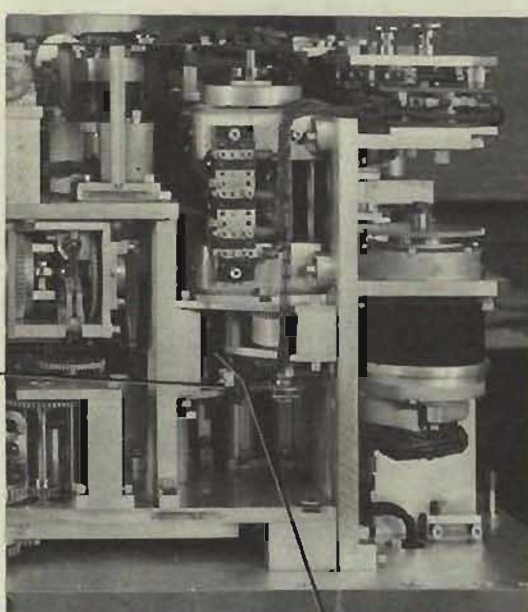
If the marks do not remain matched, slip-tighten A-127. Turn the spur gear below the clamp until the marked output gear is halfway back to its original position.
Tighten A-127.

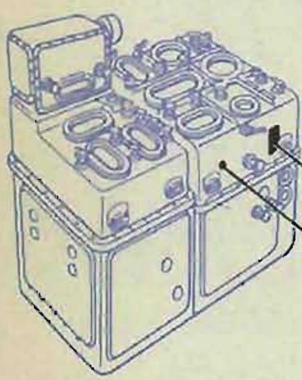
Recheck

Remove the old indicator marks and make new marks with *Br* at 90°. Turn *Br* to 270°. Check the movement of the marks. The error, if any, should be less than half-a-tooth movement of the follow-up output gear. Check that *So* can be increased to 45 knots.
Remove all wedges.
Replace the KRR lead.
Check A-121, A-119, A-101, and A-131.



A-128 dRh COMPONENT SOLVER to E DIALS





IMPORTANT

Before this readjustment is made, check and readjust A-123. When A-123 is correct, the *E* line, up to A-128, will be correct.

Location

A-128 is located under cover 1, at the right rear.

Note

A-128 can be seen from the left side of the computer. Set *dH* on 0 knots. Turn the power OFF. Insert a pencil light through the hole to the right of the *RdE* follow-up. Look into the mechanism near D-25 in front of the *jE* follow-up.

A-128 can be reached with a long screw driver from the left side of the computer. Be sure that the power is OFF. Insert the screw driver at an angle over the *Sh* contacts to reach A-128.

Possible damage

If A-128 is upset, the vector gear in the *dRh* component solver may have been run beyond its limit with such force that the hangers, gears, and shafts connected to the lead screw are damaged. To check for this, turn the power OFF. Turn the lead screw by running the *dRh* follow-up output line from limit to limit. Note any binding or sticking.

Check

Turn the power ON.

Set *E* at 0°.

The spur gear on the lead screw of the *dRh* vector gear should be toward the left.

The *dRh* component solver can be seen through the access on the right side of the front top section, just forward of the *RdBs* follow-up. It is the third component solver from the top.

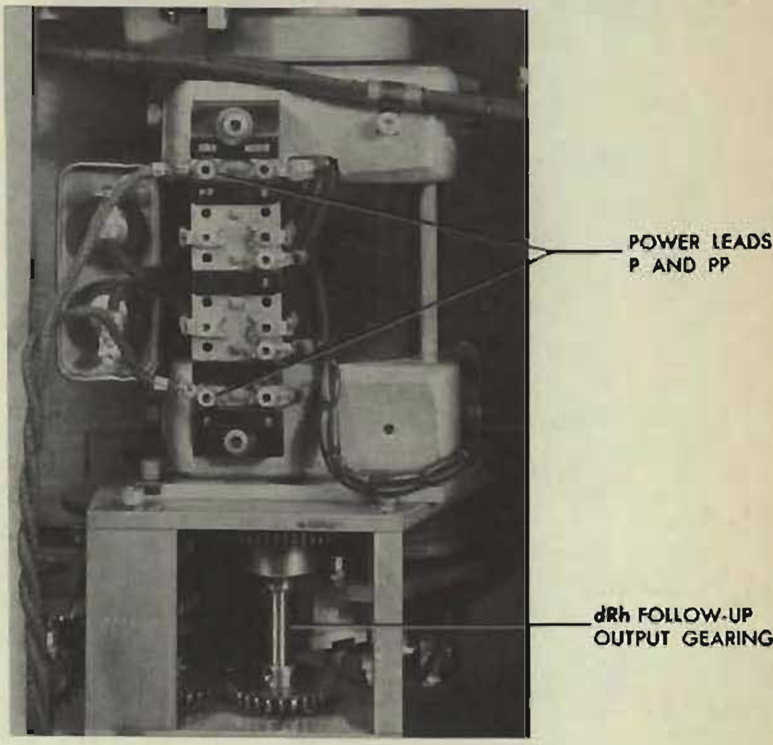
Remove leads P and PP from the *dRh* follow-up.

Turn the *dRh* output gearing to one limit of L-5.

Mark the *RdE* follow-up for use as an indicator.

Turn the *dRh* output gearing to the other limit of L-5.

The indicating marks on the *RdE* follow-up should remain matched.

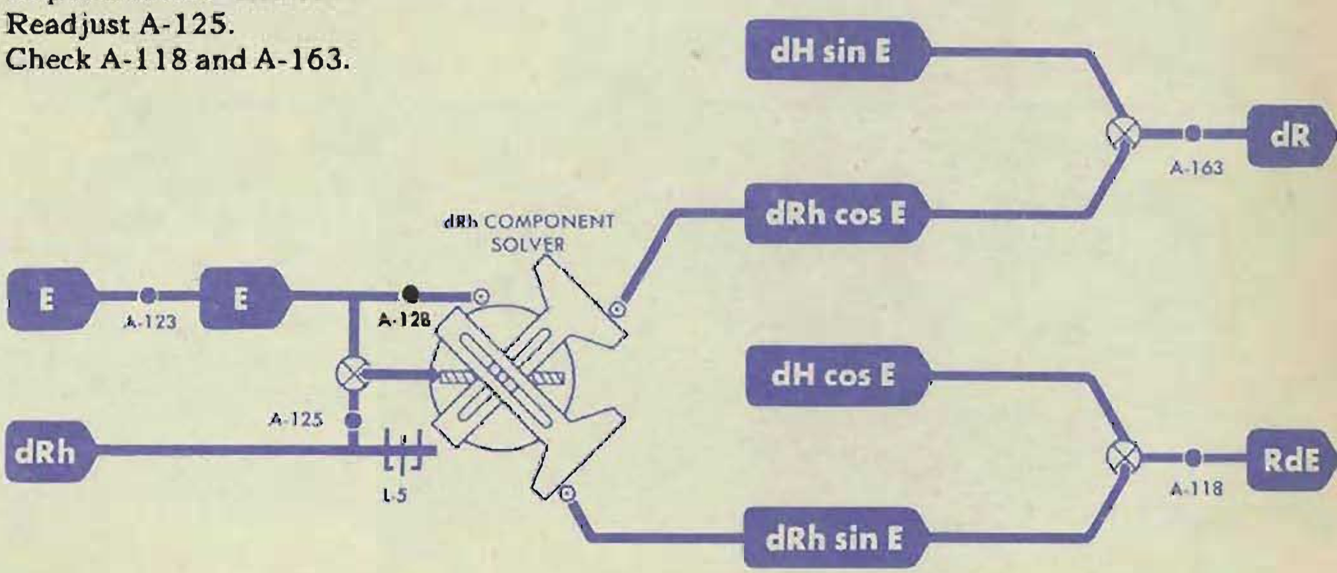


Adjustment

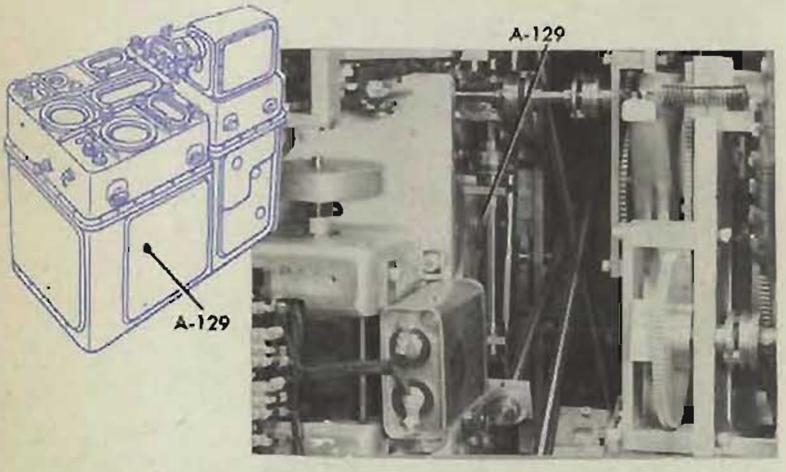
If the indicating marks do not remain matched within one half tooth, loosen A-128. Correct halfway by turning the *dRh* vector gear with a gear pusher. Tighten A-128, and recheck.

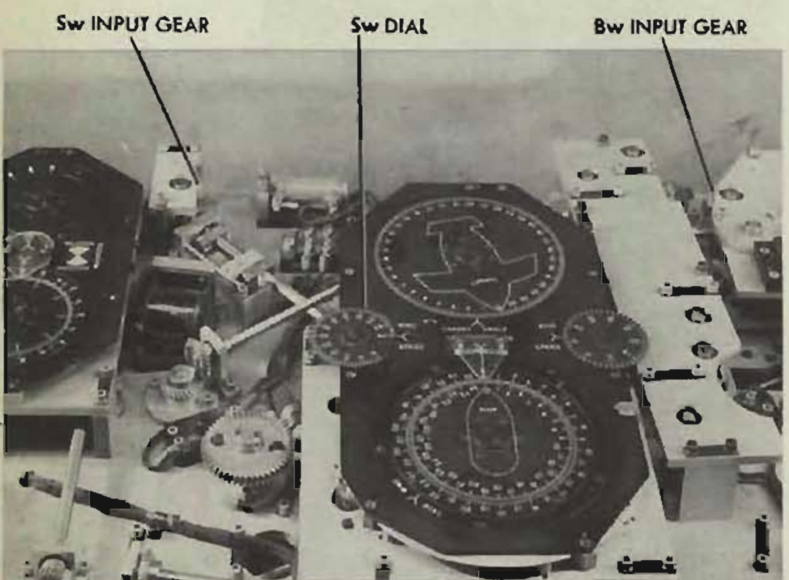
REMINDER

Replace leads P and PP.
Readjust A-125.
Check A-118 and A-163.



A-129 Sw HOLDING FRICTION





Location

A-129 is under cover 5, behind the follow-up mounting plate and in the center of the computer pedestal.

Check

The friction should be tight enough to hold the *Sw* input setting without too much drag on the line.

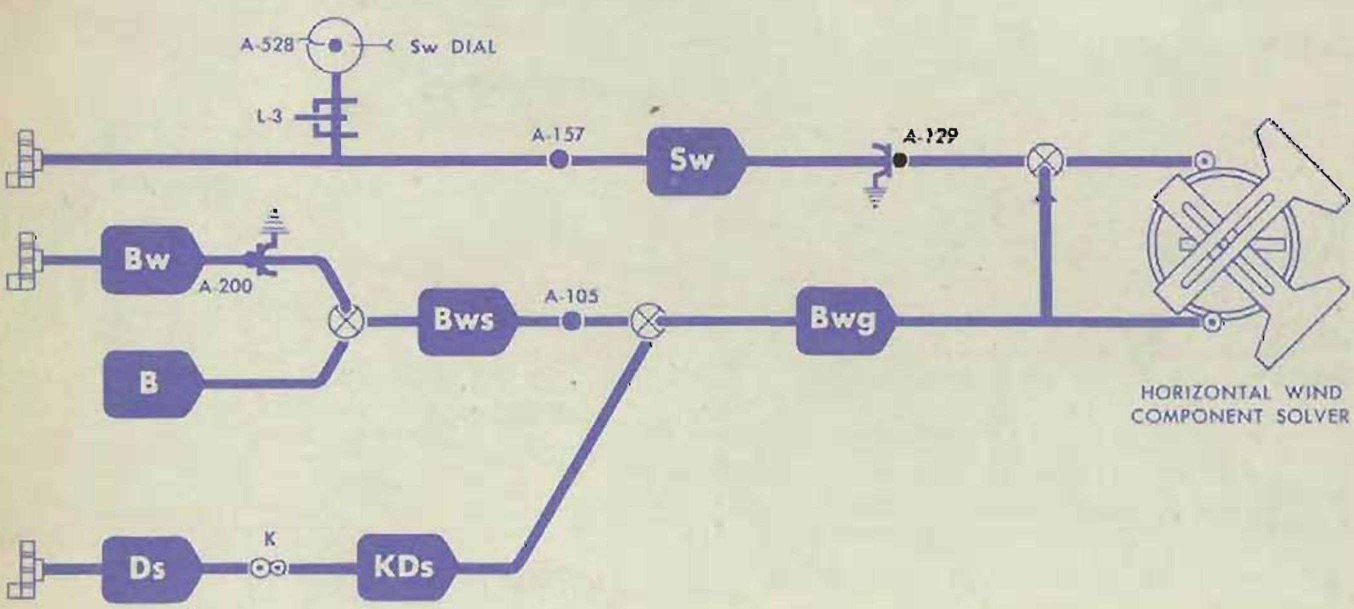
Set *Sw* at 45 knots.

Turn the *Bw* input gear. There should be no motion of the *Sw* input gear.

Adjustment

If any motion backs out on the *Sw* input gear, loosen A-129 and turn it clockwise to increase the friction.

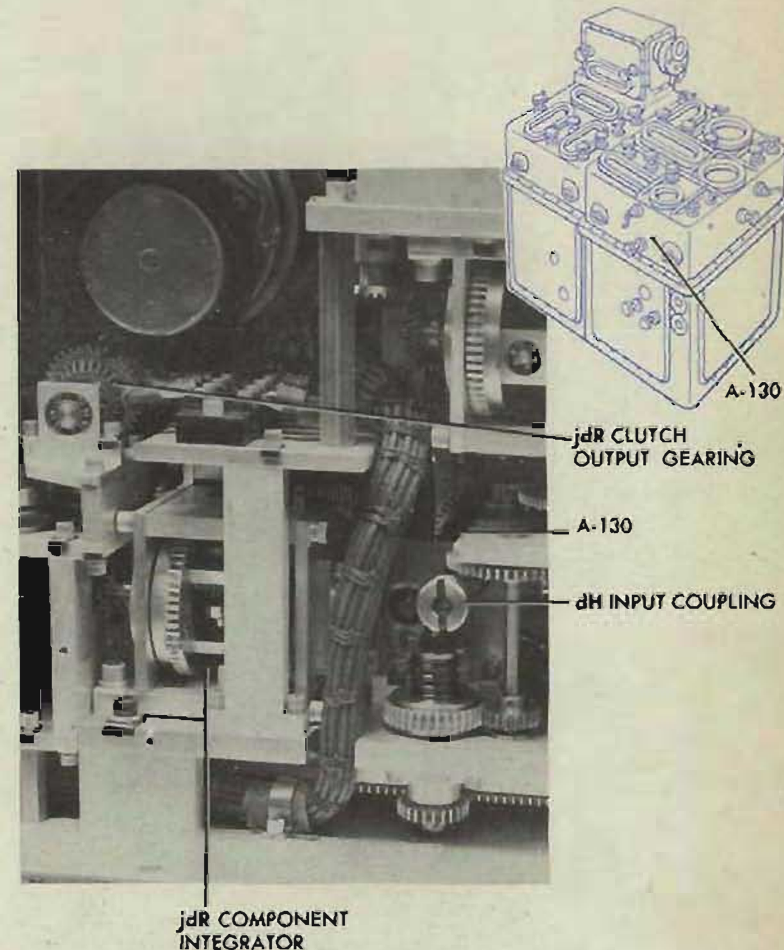
Tighten A-129, and recheck.



A-130 jHc FRICTION DRIVE

Location

A-130 is under cover 1. It is the driving friction on the *jHc* line.



Check

This friction should *slip* when *dH* is introduced manually. It should *drive* the *dH* line when there is *jHc* output from the component integrators.

Set *E* at a high value.

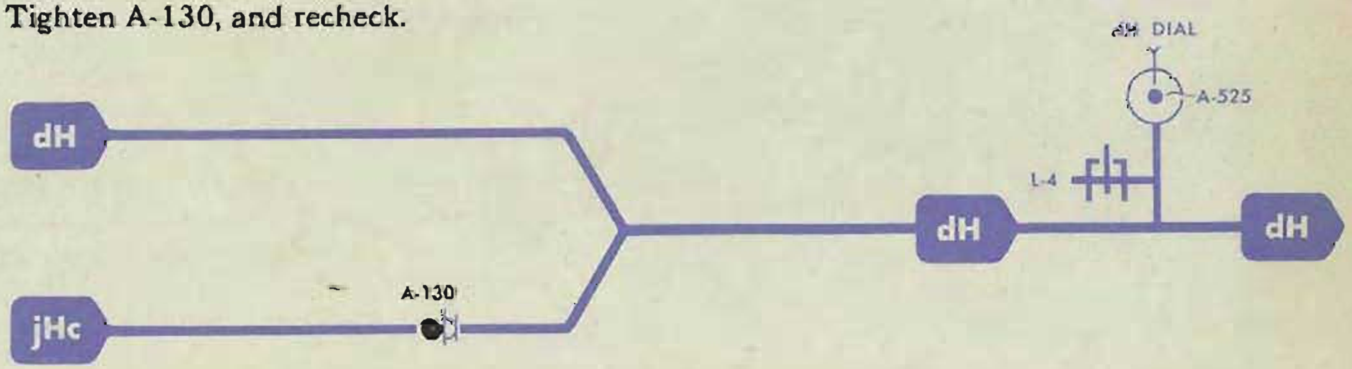
Turn the *dH* input line. The *dH* dial should move, but *dH* should not back through the *jHc* line.

Turn the output gearing of the *jdR* clutch to turn *jHc*. The *dH* line should turn and change the reading of the *dH* dial.

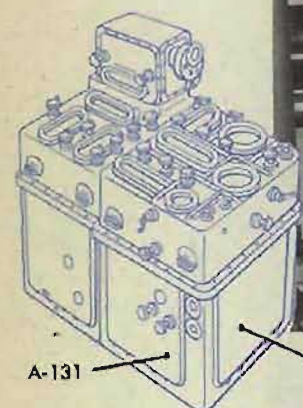
Adjustment

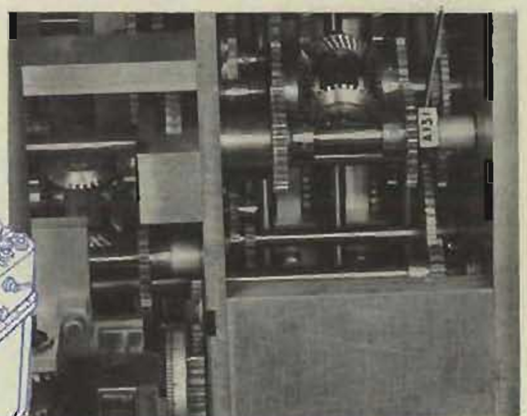
If there is no motion of the *dH* line when *jHc* is turned, loosen A-130 and turn it clockwise to increase the friction.

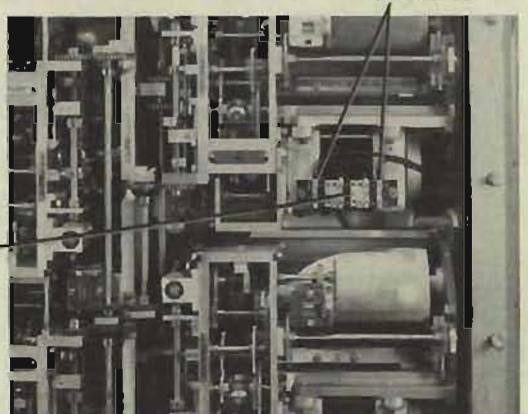
Tighten A-130, and recheck.

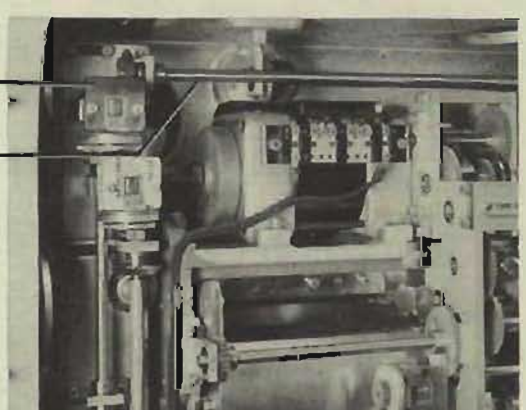


A-131 DEFLECTION MULTIPLIER to RdBs LINE









Location

A-131 is under cover 3.

Check

Remove leads B and BB from the *Tf/R2* ballistic computer.

Turn the power ON.

Set *So*, *Sh*, and *Sw* at 0 knots.
Set *Bws* at 0°.
Set *A* and *Br* at 0°.

The $K(RdBs + K_1WrD)$ input rack of the deflection prediction multiplier should now be at its zero position. At the zero position, turning the *Tf/R2* lead screw input (under cover 4) from limit to limit causes no motion of the *Dtw'* output rack.

Set the *Tf/R2* line at its lower limit by turning the shaft leading to the counter under cover 4.

Mark the *Dtwj* follow-up output gear for use as an indicator.

Turn *Tf/R2* to its upper limit. If the output gear on the *Dtwj* follow-up moves more than one tooth, A-131 is in error and should be adjusted.

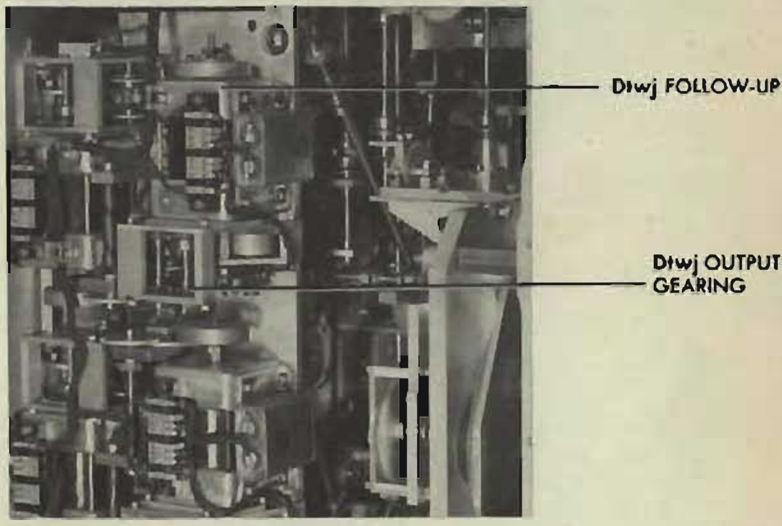
Adjustment

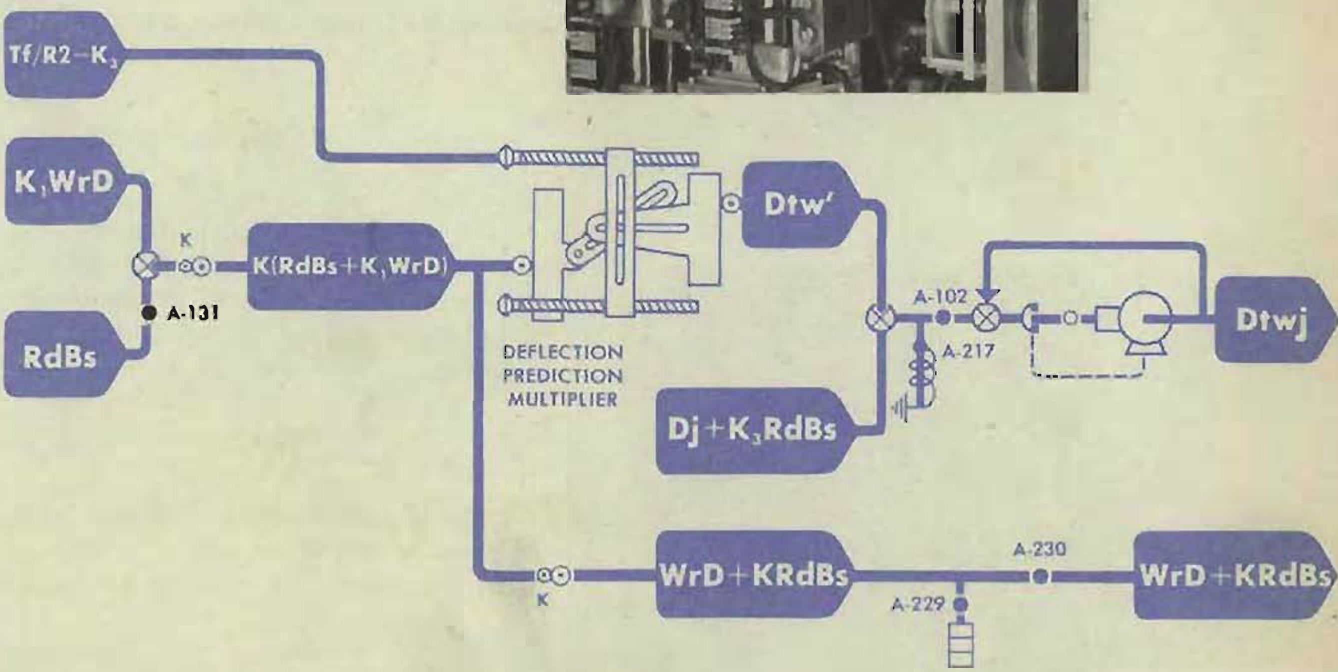
The input rack can be set approximately. Hold the spur gear behind A-131, and loosen the clamp. Turn the gear until the two teeth at the top of the input rack (the third rack from the front) are hidden by the plate. Make A-131 slip-tight.

Refining the adjustment

Repeat the check. If there is still any output on the *Dtwj* follow-up, hold *Tf/R2* at its upper limit and turn the spur gear behind A-131 to correct the full amount of motion.

Tighten A-131 and recheck.
Replace the *Tf/R2* power leads.
Check A-102 and A-229.

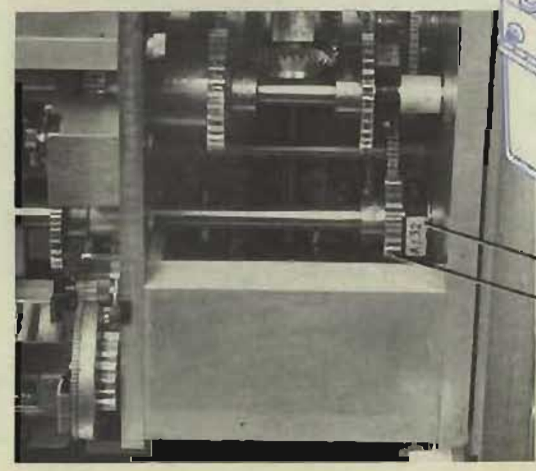


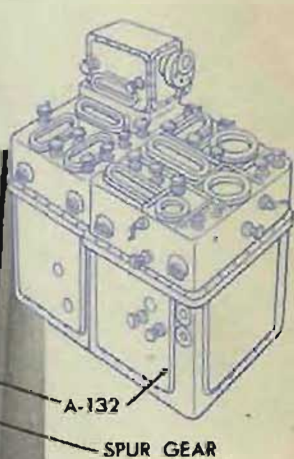


A-132 DEAD TIME MULTIPLIER to dR LINE (SER. NOS. 780 and LOWER)

Location

A-132 is under cover 3, at the lower front.

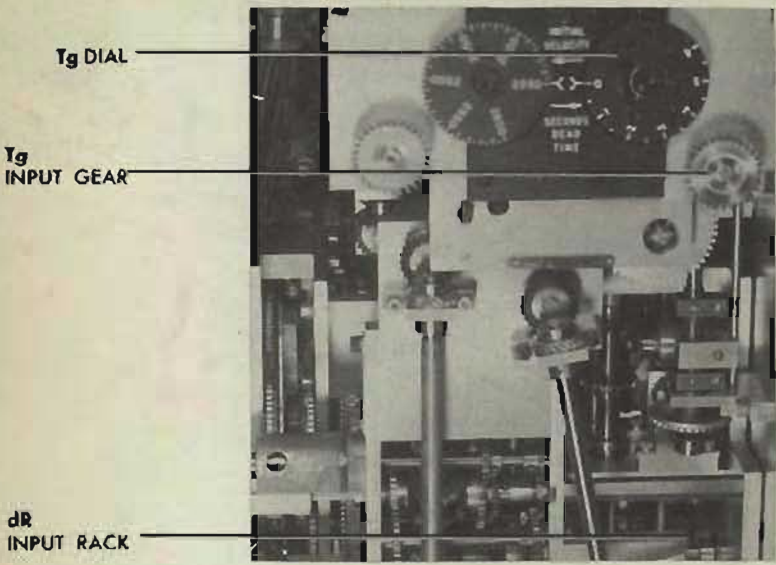




Check

Set *So*, *Sh*, and *dH* at 0 knots.
Put the *dR* handcrank at AUTO.

Turn the power ON.



The *dR* line is now at its zero position. In this position, the *RTg* output rack should not move when the *Tg* lead screw is turned.

Turn the *Tg* input from 0 to 6 seconds.

Observe the *R3* counter in the fuze ballistic computer under cover 4 for motion of the *RTg* output rack.

Adjustment

If the *R3* counter moves, first make an approximate readjustment of the input rack.

Hold the small spur gear to the rear of A-132 and loosen the clamp.

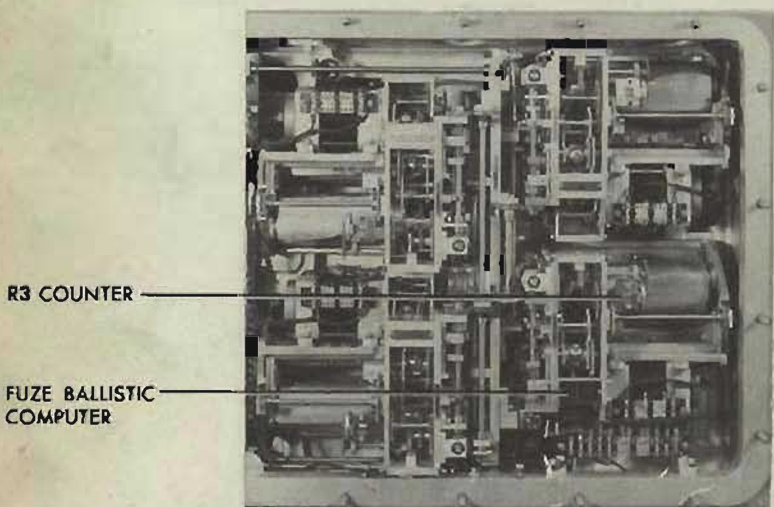
Turn the spur gear until the top two teeth of the *dR* input rack of the *Tg* prediction multiplier are hidden by the plate. The *dR* input rack is the front rack of the multiplier group.

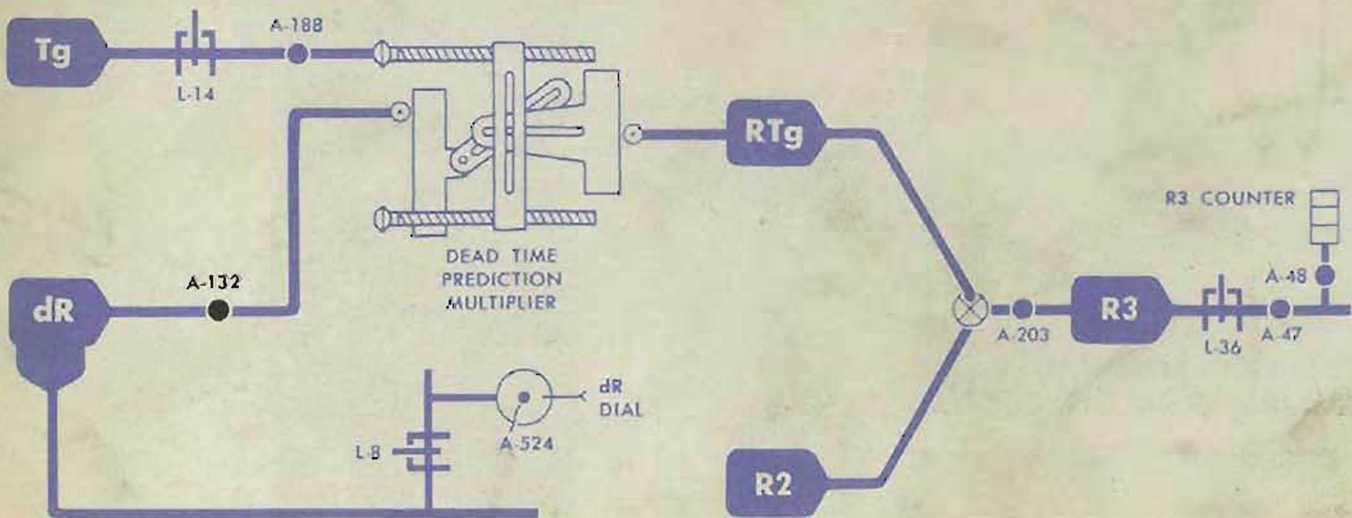
Make A-132 slip-tight.
Repeat the check.

If the *R3* counter still moves, keep *Tg* at 6 seconds and refine the adjustment by turning the spur gear to correct the full amount of motion.

Tighten A-132, and recheck.

Check A-203.

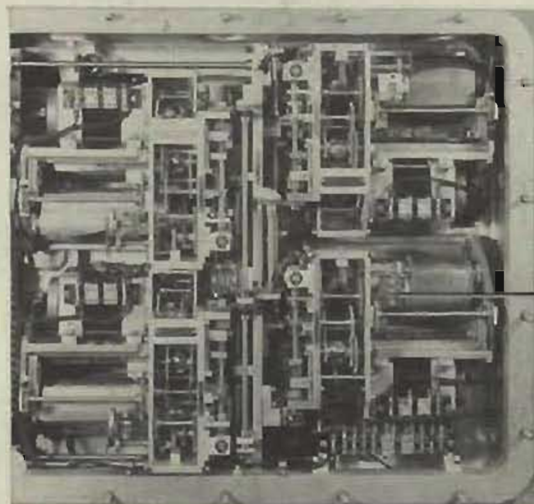




A-132 DEAD TIME MULTIPLIER to dRs – dRm LINE (SER. NOS. 781 and HIGHER)

Location

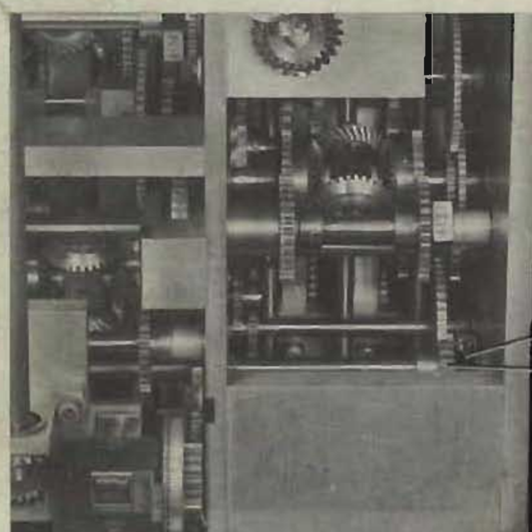
A-132 is under cover 3, at the lower front.



Check

Turn the power ON.

Set *So*, *Sh*, and *dH* at 0 knots.
Set *I.V.* at 25[illegible].
Put the *dR* handcrank in AUTO.
Put the fuze handcrank in the IN position. Turn the lead screw input from 0 to 6 seconds by turning the *Tg* input gear at the right of the *Tg* dial.
Observe the *R3* counter in the fuze ballistic computer under cover 4 for motion of the *RTg* output rack.



Adjustment

If the *R3* counter moves when *Tg* is turned, first make an approximate readjustment of the input rack. Hold the small spur gear to the rear of A-132 and loosen the clamp.

Turn the spur gear until the top two teeth of the input rack of the *Tg* prediction multiplier are hidden by the plate. The input rack is the front rack of the multiplier group.

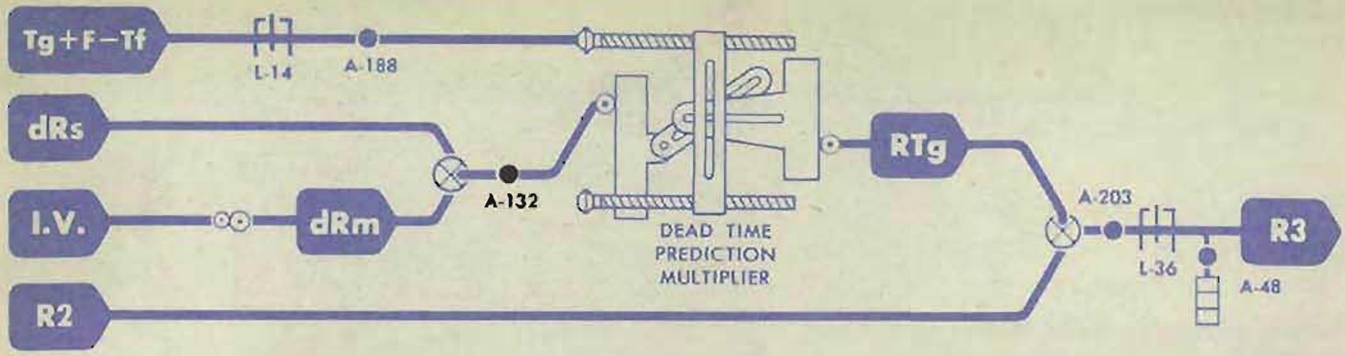
Make A-132 slip-tight.

Repeat the check.

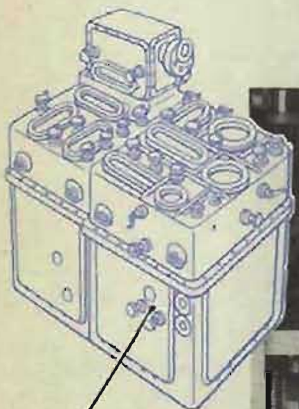
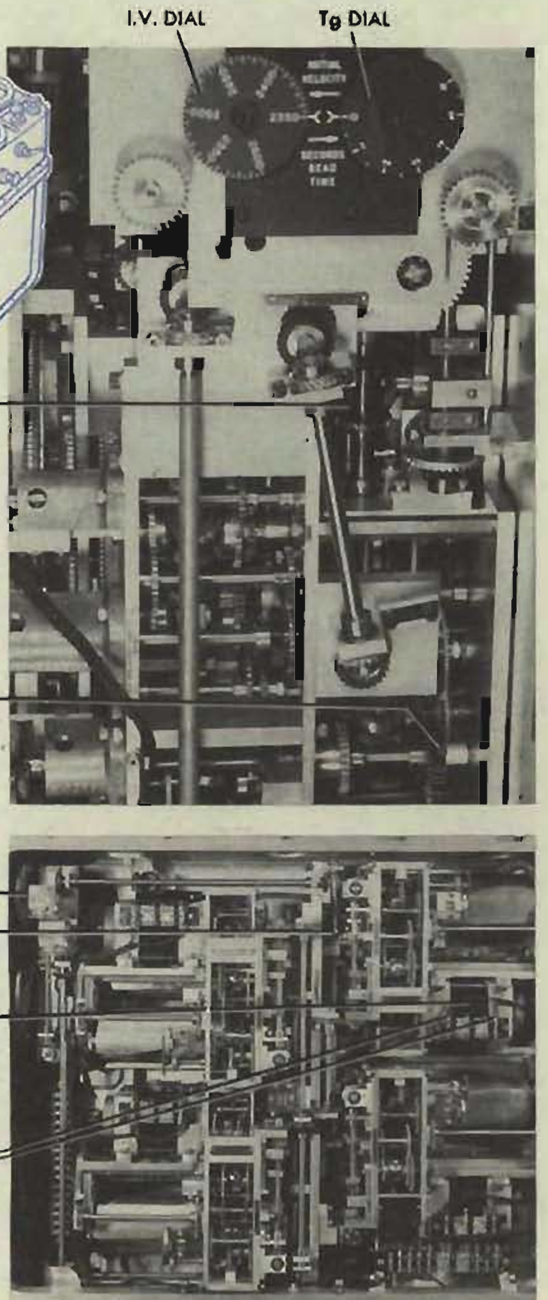
If the *R3* counter still moves, keep *Tg* at 6 seconds and refine the adjustment by turning the spur gear to correct the full amount of motion.

Tighten A-132, and recheck.

Check A-203.



A-133 DEFLECTION MULTIPLIER to Tf/R2 COUNTER

Location

A-133 is under cover 3.

Check

Remove leads B and BB from the *Tf/R2* ballistic computer. Set the *Tf/R2* counter at 0.00125 (0.001184 for Mods 8 and 12) by turning the gearing leading to the counter and wedge the line.

Turn the power ON.

The lead screw input of the deflection prediction multiplier should now be positioned so that motion of the $K(RdBs+K_1WrD)$ input rack causes no motion of the *Dtw'* output rack.

Motion of the *Dtw'* rack can be observed on the *Dtwj* follow-up output gearing.

To move the $K(RdBs+K_1WrD)$ input rack independently, loosen A-131. Turn the spur gear to the rear of the clamp until the input rack is at one limit.

Mark the *Dtwj* follow-up for use as an indicator. Turn the gear next to A-131 to the other limit of the rack. Note any motion of the indicating gear. If there is motion of more than one tooth, A-133 is in error and should be readjusted.

Adjustment

Loosen A-133 and turn the small gear above it in a decreasing direction until the lead-screw input reaches its lower limit.

Check the decreasing direction by decreasing *Tf/R2* and observing the motion of the small gear.

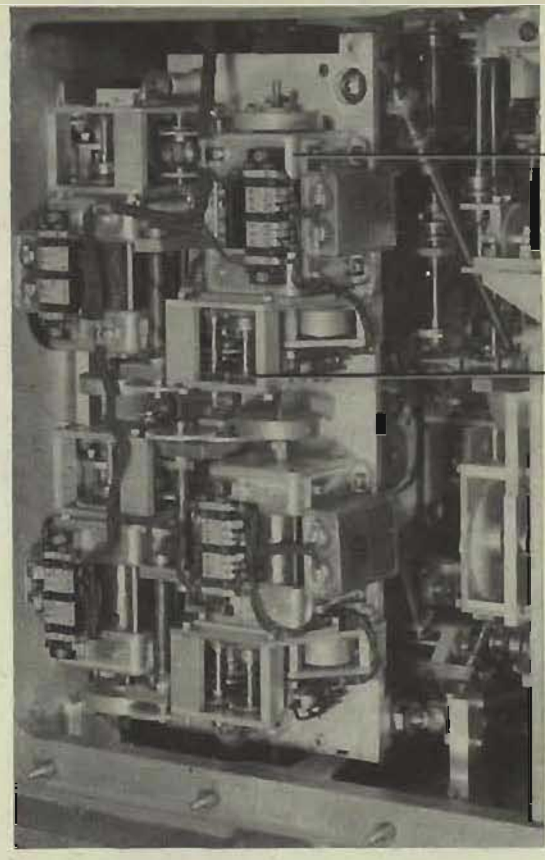
Hold the gear against the limit and set the *Tf/R2* counter at 0.001198 (0.001146 for Mods 8 and 12).

NOTE: Before this value can be reached, A-78 must be loosened.

Make A-133 slip-tight.

Turn the *Tf/R2* shaft and lead screw until the counter reads 0.00125 (0.001184 for Mods 8 and 12).

Wedge the *Tf/R2* gearing.



Refining the adjustment

Repeat the check. If the adjustment is still off, correct by turning the spur gear directly above the clamp until moving the multiplier input rack from limit to limit causes no motion of the *Dtwj* follow-up output gearing.

Hold the spur gear above A-133 and slip the *Tf/R2* shaft until the counter reads 0.00125 (0.001184 for Mods 8 and 12).

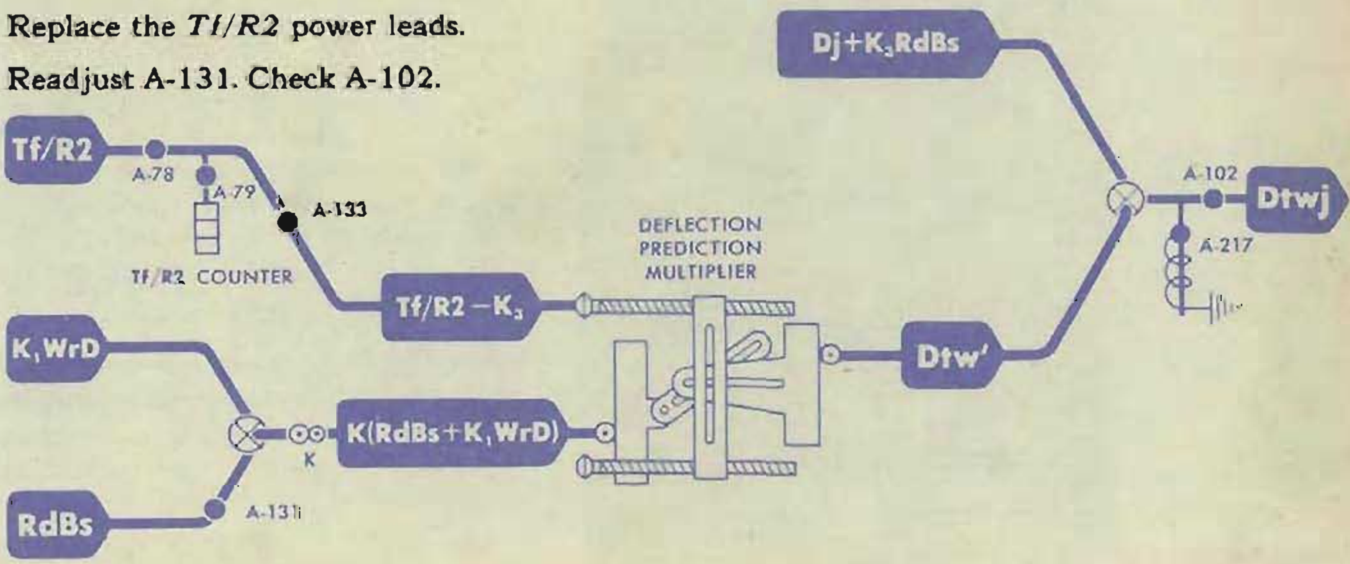
Tighten A-133, and recheck.

Readjust A-78.

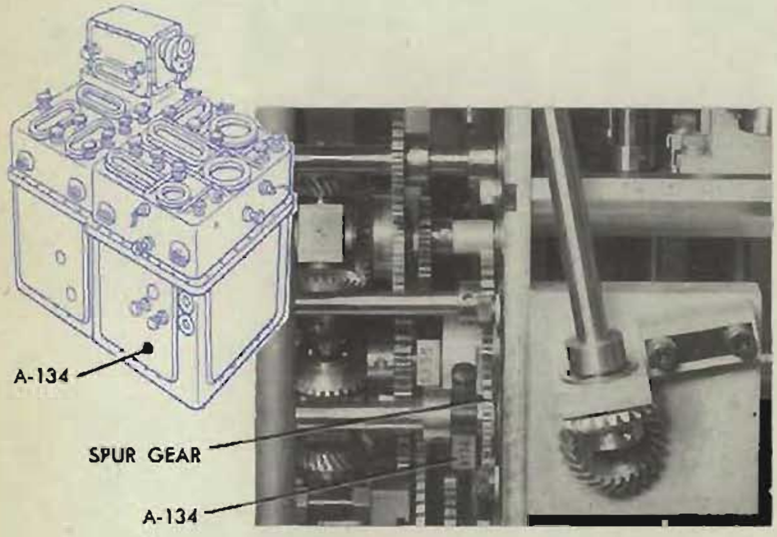
Remove all wedges.

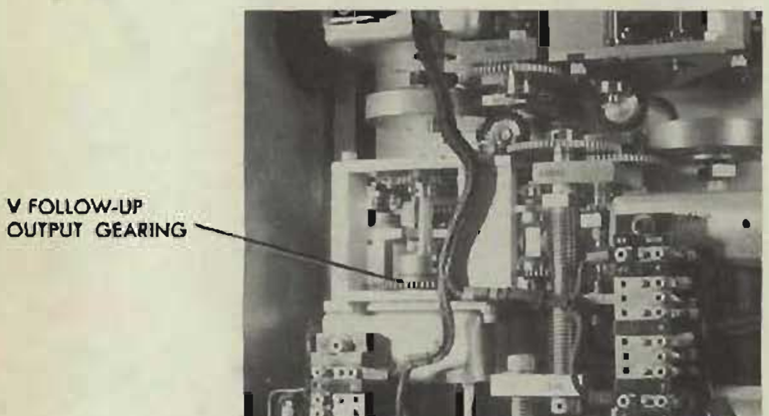
Replace the *Tf/R2* power leads.

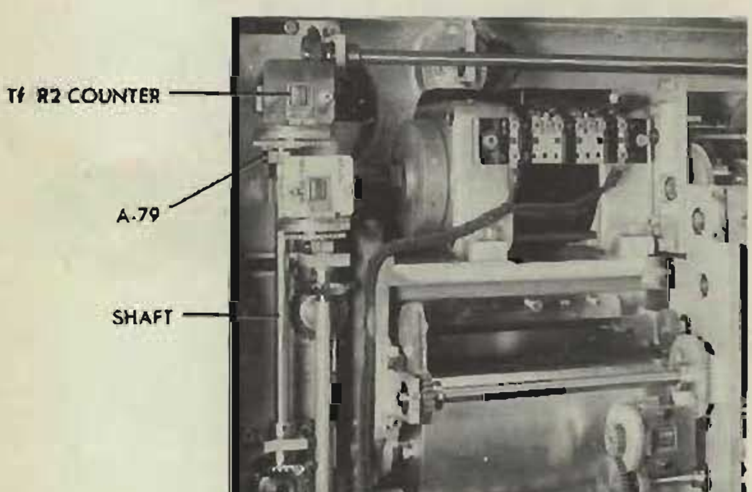
Readjust A-131. Check A-102.



A-134 ELEVATION MULTIPLIER to WrE LINE







Location

A-134 is under cover 3, on a horizontal shaft about 14 inches below the center of the *I.V.* dial mask.

Check

Turn the power ON.

Set *So*, *Sh*, *Sw*, and *dH* at 0 knots.
Set *E2* at 0°.

The $K(RdE - K_{,}WrE)$ input rack of the elevation prediction multiplier should now be at its zero position, where movement of the *Tf/R2* lead-screw input causes no motion of the *Vtw'* output rack.

The *V* follow-up output gearing is used to indicate motion of the *Vtw'* output rack.

Remove the power leads from the *Tf/R2* ballistic computer.

Set *Tf/R2* at its lower limit.
Mark the *V* follow-up output gearing.

Turn the *Tf/R2* shaft below A-79 under cover 4, until the *Tf/R2* lead-screw input is at its upper limit. If the motion is more than one tooth on the *V* follow-up, A-134 is in error and should be readjusted.

Adjustment

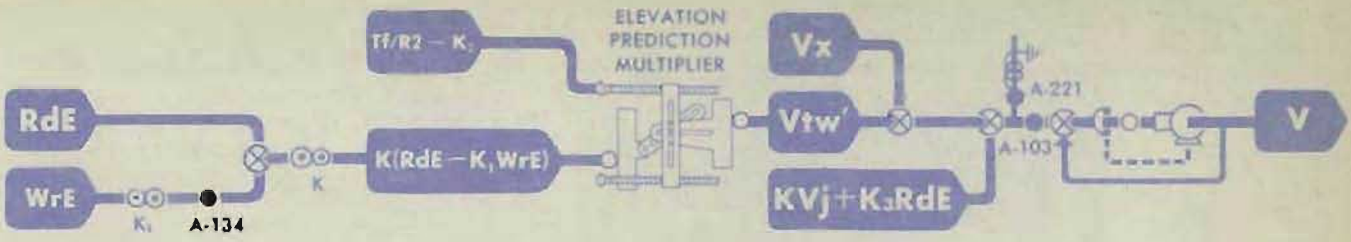
If the *V* follow-up output gearing moves more than one tooth, hold the spur gear next to A-134 and loosen the clamp.

Turn the spur gear until the top two teeth of the $K(RdE - K_{,}WrE)$ input rack are hidden by the plate. This rack is the second from the front.

Make A-134 slip-tight.
Repeat the check. If there is any motion of the *V* follow-up, correct by turning the spur gear until there is no output for full travel of the multiplier lead-screw input.

Tighten A-134, and recheck.

Check A-103.



A-135 RANGE MULTIPLIER to dRs LINE

Location

A-135 is under cover 3, below the *I.V.* dial.

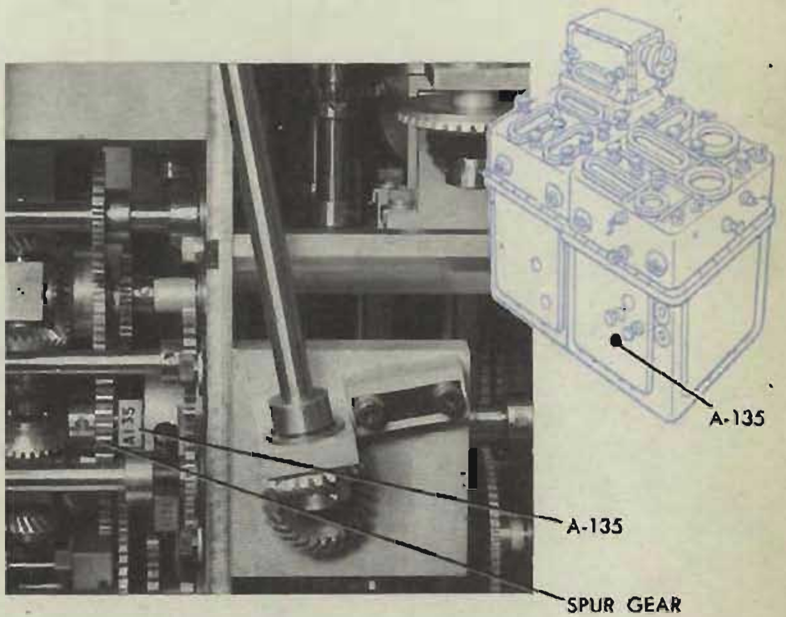
Check

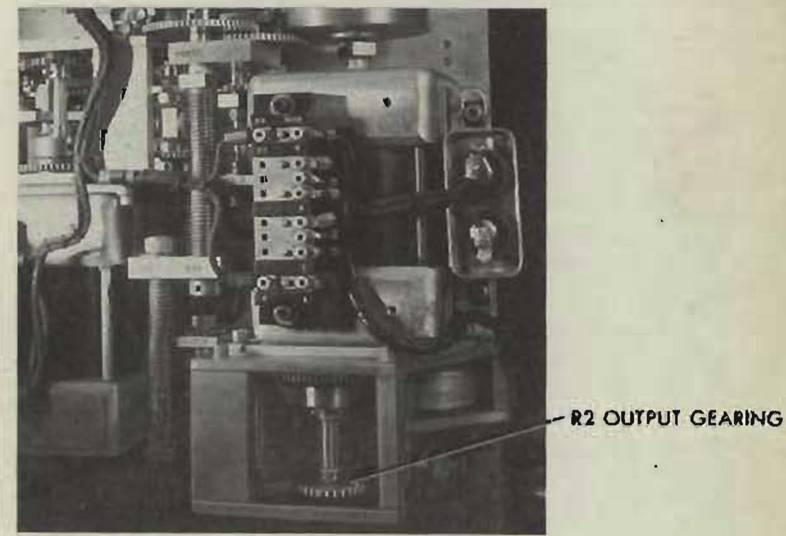
Disconnect leads A and AA from the *Tf* ballistic follow-up.
Set I.V. at 2550 f.s.
Turn the power ON.
Set *So*, *Sh*, *Sw* and *dH* at 0 knots.
Set *A* and *Br* at 90°.
Set *E2* at 78.95°. (On Mods 8 and 12, set *E2* at 80.496°.)

The $K(dRs + K_1WrR)$ input rack of the range prediction multiplier should now be at its zero position, where movement of the *Tf* lead-screw input causes no motion of the *Rtw'* output rack.

The *R2* follow-up output gearing is used as an indicator of motion of the *Rtw'* output rack.

Turn *Tf* from its lower limit to its upper limit by turning the horizontal shaft below the $Vf + Pe$ ballistic computer.



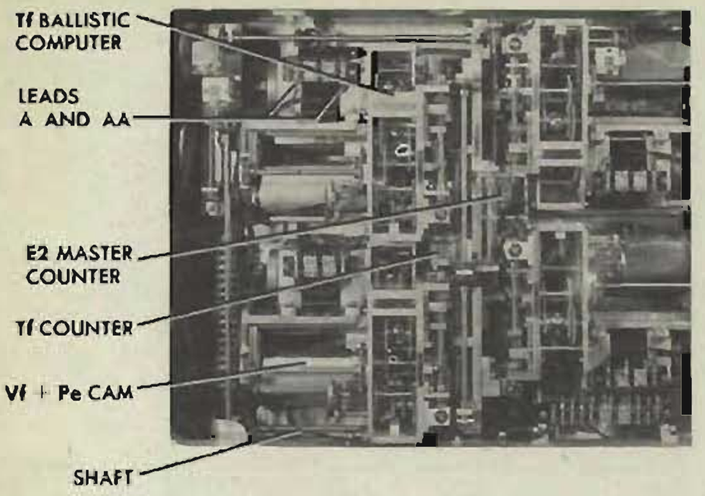


Adjustment

If there is any motion of the *R2* follow-up output gearing, hold the small spur gear at the rear of A-135 and loosen the clamp.

Turn the gear until the top of the $K(dRs + K_1WrR)$ input rack can be seen. This rack is the rear rack of the group. Continue turning the gear until the top two teeth are hidden by the mounting plate.

Make A-135 slip-tight.



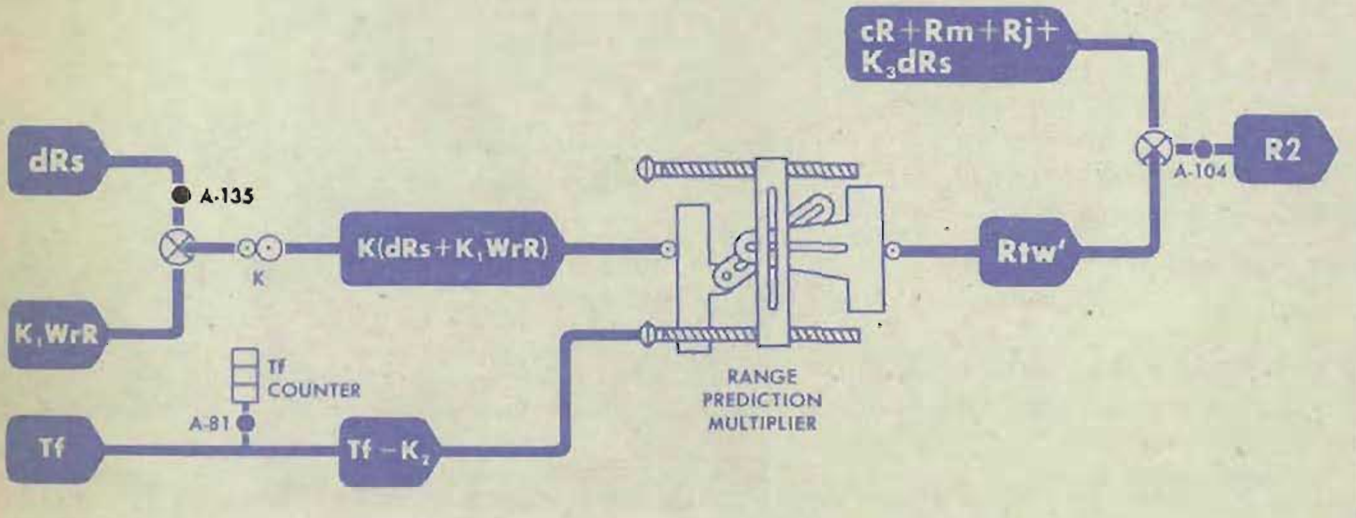
Refining the adjustment

Set *Tf* at 5.00 seconds (or 8.00 seconds on Mods 8 and 12) and make a new indicating mark on the *R2* follow-up output gearing.

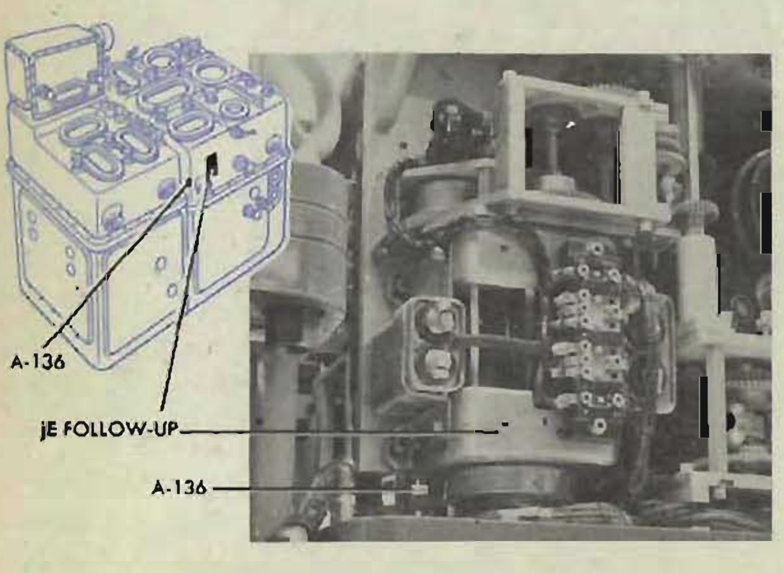
Turn *Tf* to its upper limit and observe the *R2* follow-up.

Correct all the way by turning the gear behind A-135 until the indicating marks match again. Repeat until there is no output when the *Tf* lead screw is turned.

Tighten A-135, and recheck.
Reconnect the *Tf* power leads.
Check A-104.



A-136 VECTOR SOLVER to A DIAL



Location

A-136 is under cover 1, at the rear.

Check

Turn the power OFF.

NOTE:

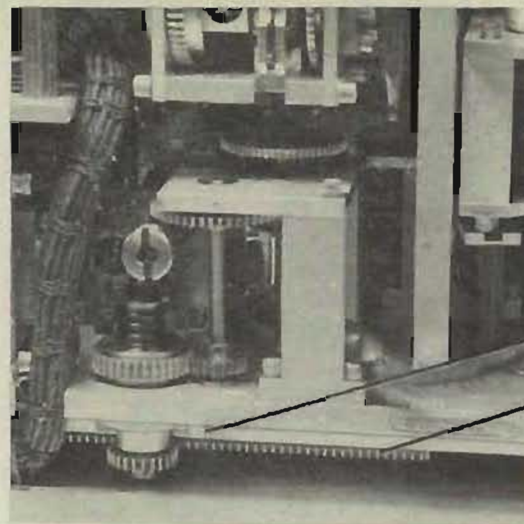
Check A-137 and A-532 before checking this adjustment.

Set *B* at 0° by setting *Co* and *Br* at 0°.
Set *A* at 0°.
Increase *Sh* from 0 knots to 400 knots.
The N-S rack of the vector solver should move toward the front of the computer.

Turn *A* to 270° and wedge the line. Make a mark on one tooth of the N-S rack of the vector solver and a matching mark on the rail above it.

With *B* at 0° and *A* at 270°, decrease *Sh* from 400 to 0 knots.

The pencil marks should remain matched.



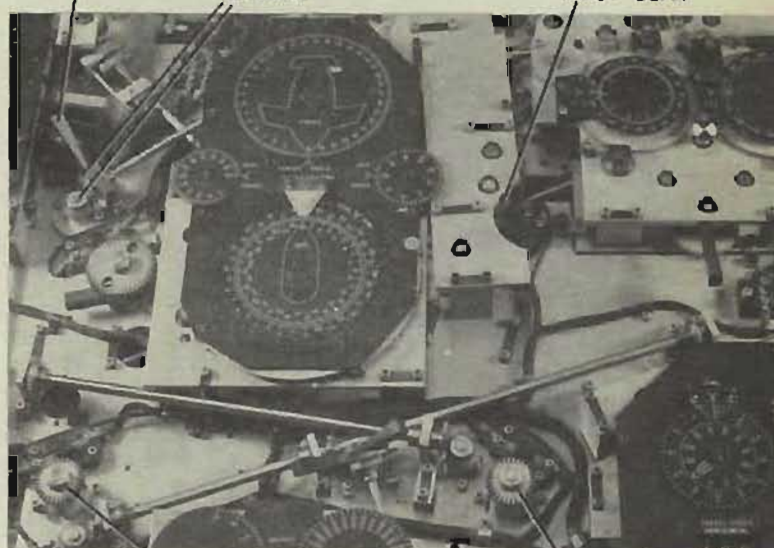
Adjustment

If there is any motion of the N-S rack, set *Sh* at 0 knots. Make new indicating marks on the N-S rack and rail.

Increase *Sh* to 400 knots. Loosen A-136. Remove the wedges in the *A* line.

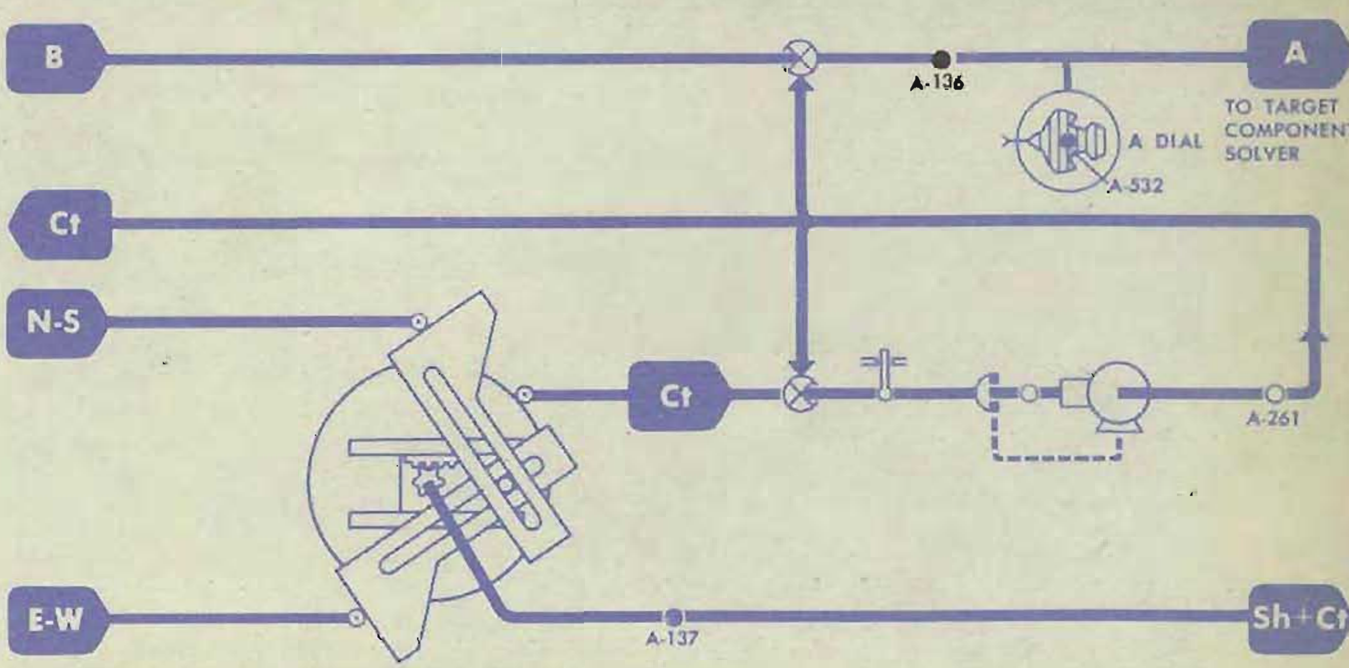
Turn the *A* input gear until the new indicating marks match. Hold the *A* input gear and bring the *A* dials back to 270° by turning the bevel gears on the shaft to the *A* dial.

Tighten A-136, and recheck.

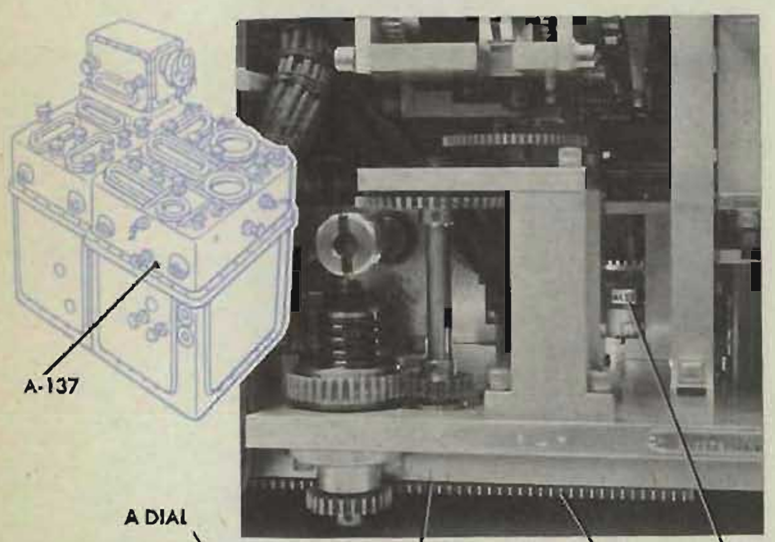


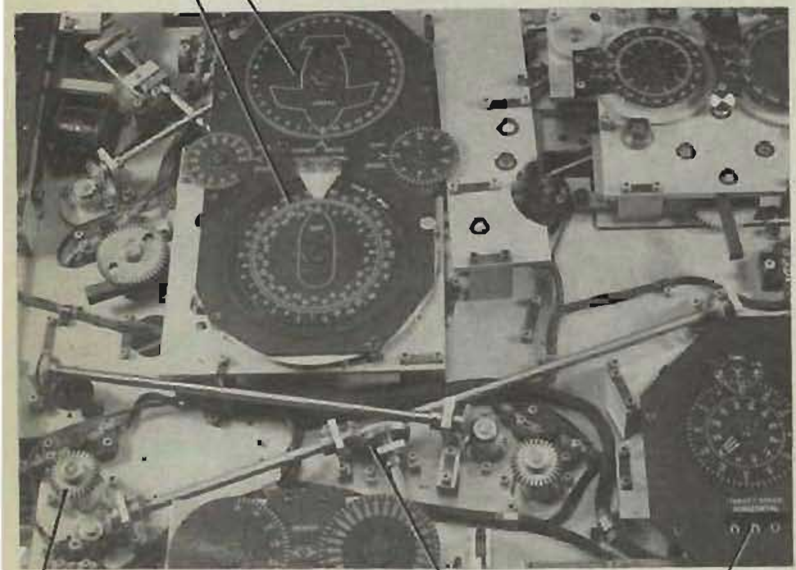
CAUTION

When tightening A-136, make sure that the gear near the clamp is all the way down so that it does not interfere with the small spring on the *Ct* follow-up contact arm.



A-137 VECTOR SOLVER to Sh COUNTER





Location

A-137 is under cover 1, to the rear of the *Sh* motor.

Note

Before adjusting A-137, loosen frictions A-205 and A-206.

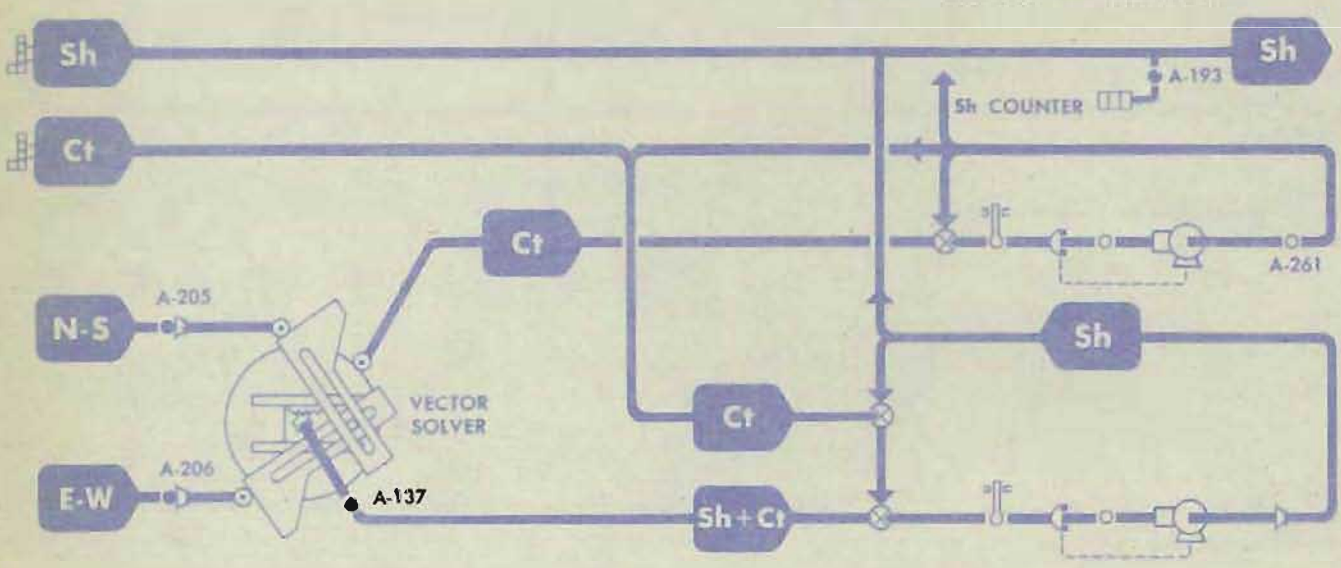
Do not increase *Sh* until A-137 is adjusted. If A-137 is out of adjustment, the *Sh* speed pin rack may drive out of mesh with its pinion.

Check

Set *Sh* at 0 knots and wedge the line. The speed pin of the vector solver should be at its zero position, so that an input of *Ct* causes no motion of either rack.
Turn *A* through 360°.
The N-S rack can be checked for motion by eye.

Adjustment

If there is any motion of the N-S rack:
Set *B* at 0° by setting *Co* and *Br* at 0, and wedge the lines.
Set *Sh* at 0 knots and wedge the line.
Set *A* at 270°.
Make matching marks on the N-S rack of the vector solver and the rail above it. Turn *A* to 0°.
Loosen A-137 and turn the spur gear above it to rematch the marks.
Tighten A-137 and recheck by watching the N-S rack for motion when *A* is turned through 360°.
Remove the wedges.
Readjust A-205 and A-206.

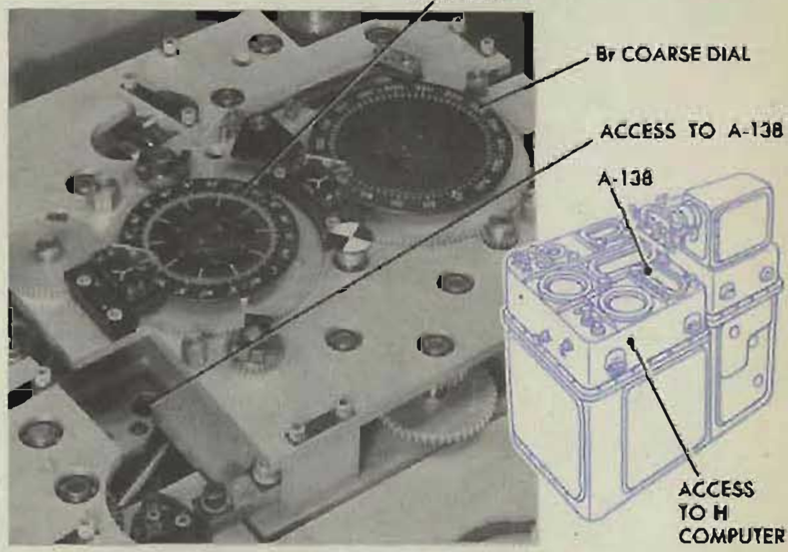


A-138 HEIGHT COMPUTER to cR DIALS

Location

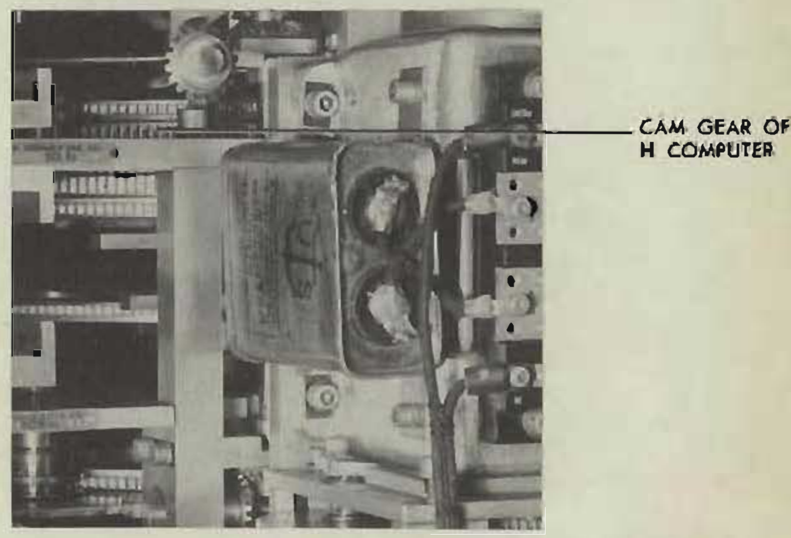
A-138 is under cover 1, at the left front edge of the fine *Br* dial.

To reach A-138, remove the *Br* dial mask. A-138 can be seen and reached through a small access hole near the front of the index on the fine *Br* dial.



Check

Set *E* at 30°.
Set *cR* at 8000 yards.
The *H* dials should read 12,000 feet.



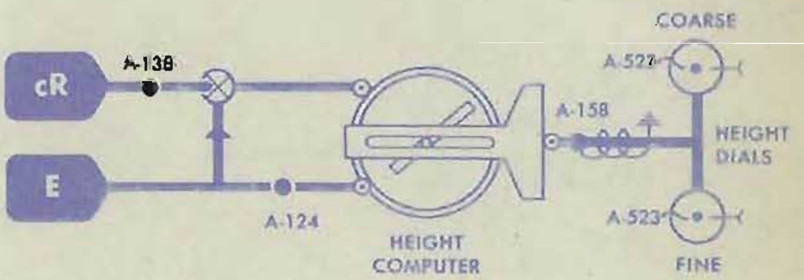
Adjustment

If the *H* dials do not read 12,000 feet, make A-138 slip-tight. Use a gear pusher to turn the height computer cam until the *H* dials read 12,000. The height computer is the top component solver in the relative motion component solver group.

Tighten A-138 and recheck at the values of *cR* given in the table. Set *cR* on these values from both an increasing and a decreasing direction to check for spread of error due to lost motion.

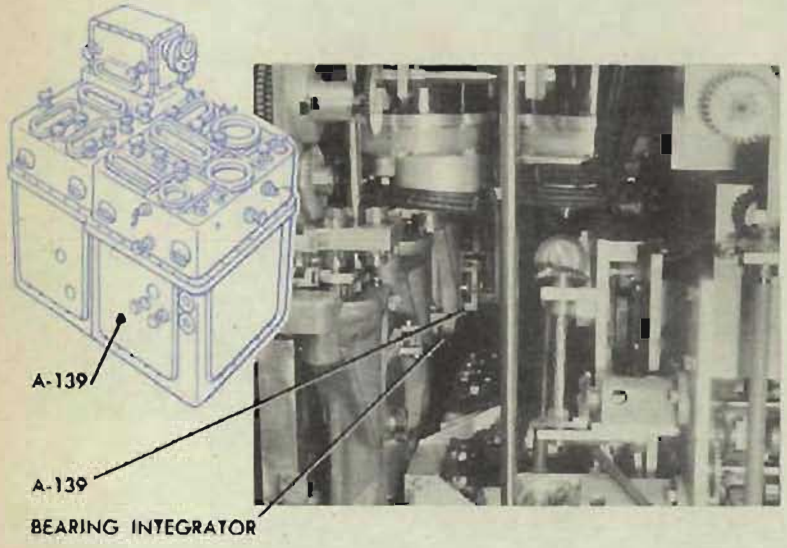
H CHECK VALUES

cR	*E*	*H*
2,000 yards	30°	3,000 feet
10,000 yards	30°	15,000 feet
30,000 yards	30°	45,000 feet



Check A-522 and A-523.

A-139 and A-140 BEARING INTEGRATOR to RdBs LINE



Location

A-139 is under cover 3, on the spur gear of the carriage input to the bearing integrator. A-140 is to the rear of A-139, under cover 5.

A-139 is the vernier adjustment screw. A-140 is the coarse adjustment clamp.

Check

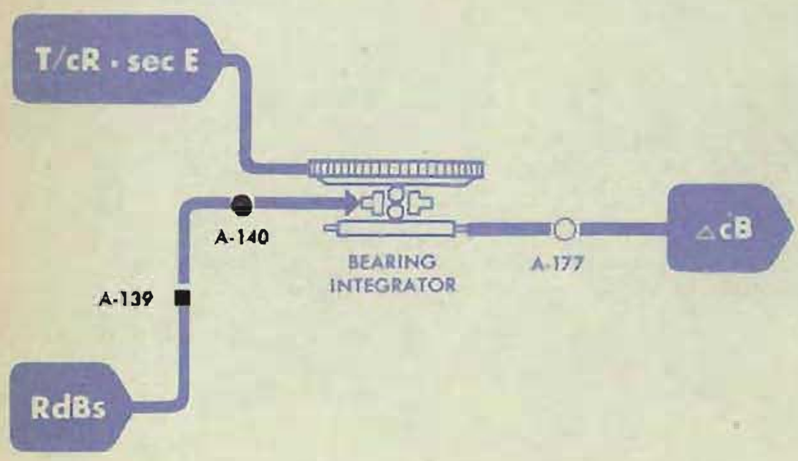
Turn the power ON.

Set *So* and *Sh* at 0 knots.
Set *A* at 0°.
Set *cR* at 5000 yards.
Set *Br* at 0°.
The *RdBs* line is now at its zero position.
The carriage of the bearing integrator should be at the center of the disk.
Start the time motor to rotate the disk.
There should be no motion of the bearing integrator roller while the disk is turning.

Adjustment

If there is any motion of the integrator roller, check A-140. If it is loose, push the integrator carriage to the approximate center and tighten A-140. Loosen the locking screw of A-139 and turn the vernier adjustment screw until there is no movement of the output roller.

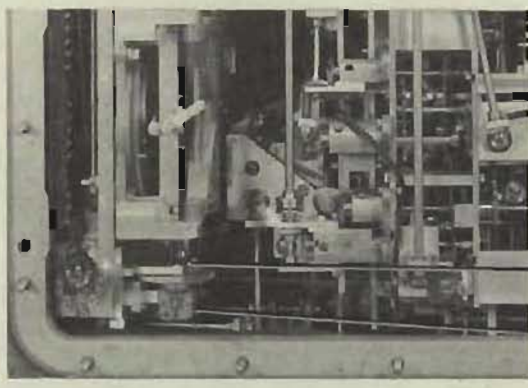
Tighten the locking screw and recheck.
Recheck the bearing B tests.



A-141 ASSEMBLY CLAMP

Location

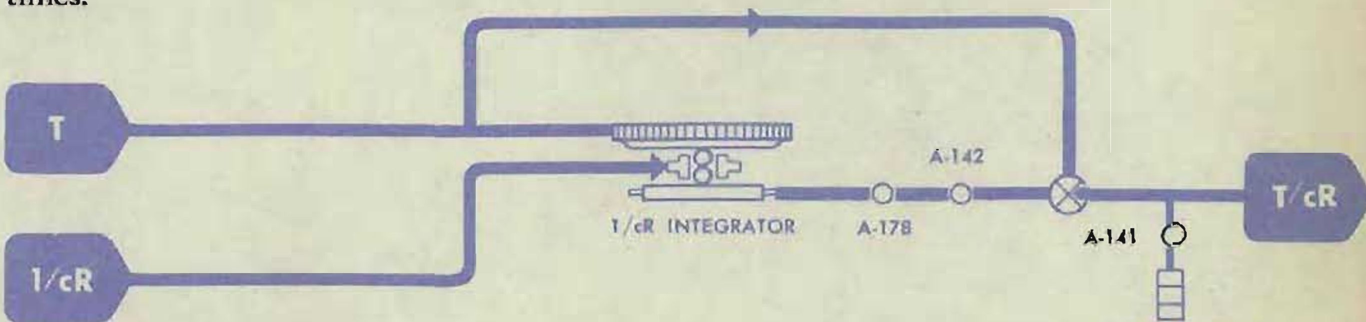
A-141 is under cover 3, on the gear meshing with the *T/cR* counter gear. On later instruments the gear on which A-141 is mounted slides out of mesh with the counter gear.



Check

If a sliding gear is provided, A-141 should be tightened with the gear out of mesh except while the integrators are being timed.

On the earlier instruments, A-141 should be tightened in mesh at all times.



A-142 ASSEMBLY CLAMP

Location

A-142 is under cover 5, and is one of two clamps on the roller output coupling of the 1/*cR* integrator.

Check

See the readjustment procedure of A-178.

A-143 ASSEMBLY CLAMP

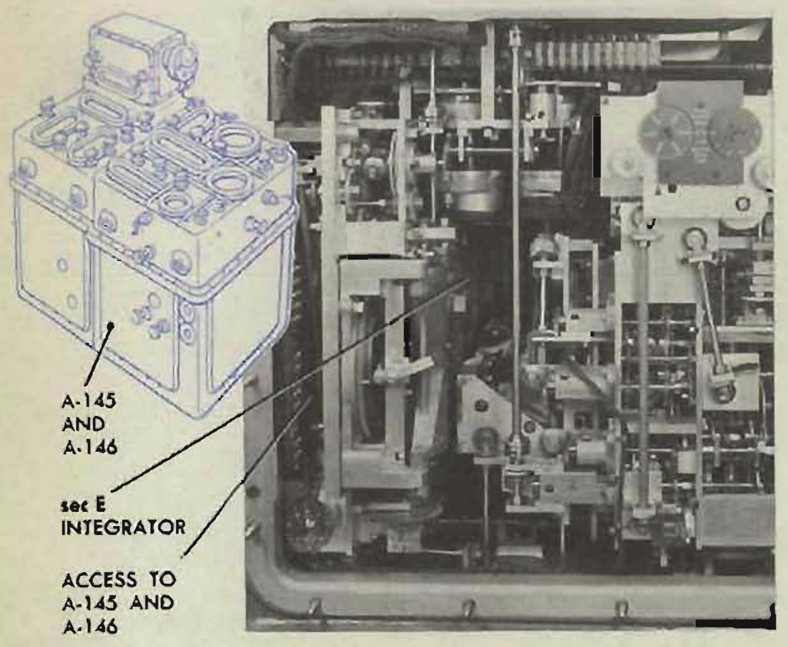
Location

A-143 is under cover 3, and is one of the two clamps on the roller output coupling of the sec *E* integrator.

Check

See the readjustment procedure of A-176.

A-145 and A-146 SECANT E CAM to E DIALS



Location

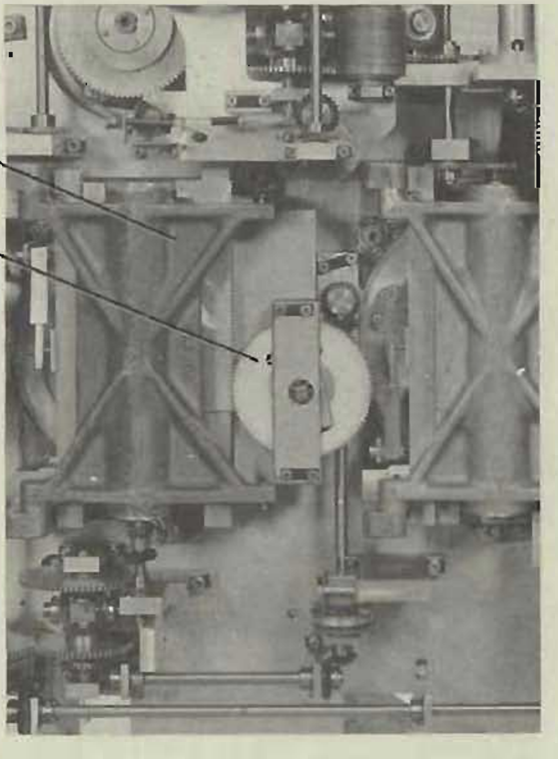
A-145 and A-146 are under cover 3, at the lower rear, behind the sec *E* cam.

A-145 is the vernier adjustment screw. A-146 is the coarse adjustment clamp. (A-210 is used in place of A-146 in earlier instruments.)

Note

In instruments with Ser. Nos. 389 and lower, A-146 is an assembly clamp. Check that it is tight. See A-210.

In instruments with Ser. Nos. 390 and higher, A-146 is an adjustment clamp.



Check

Increase *E* until the sec *E* cam follower just ceases to move. This is the start of the outer constant radius of the cam.

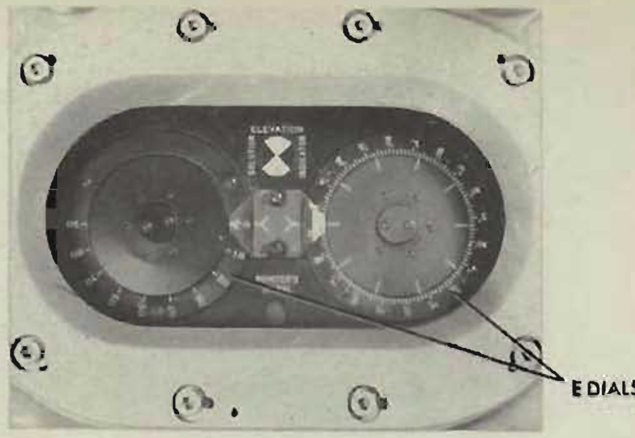
Motion of the follower can be observed on the spur gear of the carriage input to the sec *E* integrator.

INTEGRATOR ASSEMBLY REMOVED FROM THE COMPUTER

The sec *E* cam is then at a position where further movement of the cam does not move the cam follower. Note the reading of the *E* dials.

Increase *E* above 80°.
Decrease *E* steadily until the follower just starts to move.
Note the reading of the *E* dials.

The average of the two readings should be 71° 12′.



Adjustment

If the average reading of *E* is not 71° 12′, first check A-146 (A-210 in earlier instruments). If it is loose, set *E* at 71° 12′ and turn the cam until the follower just starts to move. Tighten A-146.

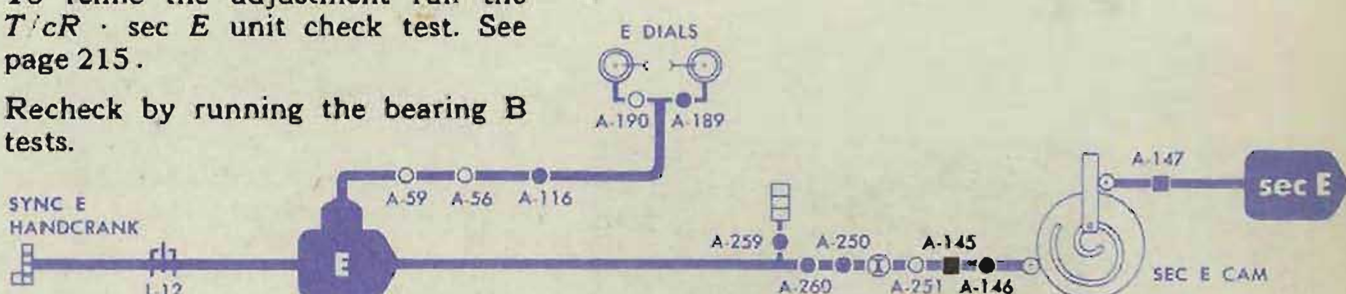
If A-146 is tight but the average reading of *E* is not 71° 12′, loosen the A-145 locking screw and turn the A-145 vernier adjustment screw until the average reading is correct.

Tighten the locking screw and recheck.

Note

This is a preliminary adjustment. To refine the adjustment run the *T/cR* · sec *E* unit check test. See page 215.

Recheck by running the bearing B tests.

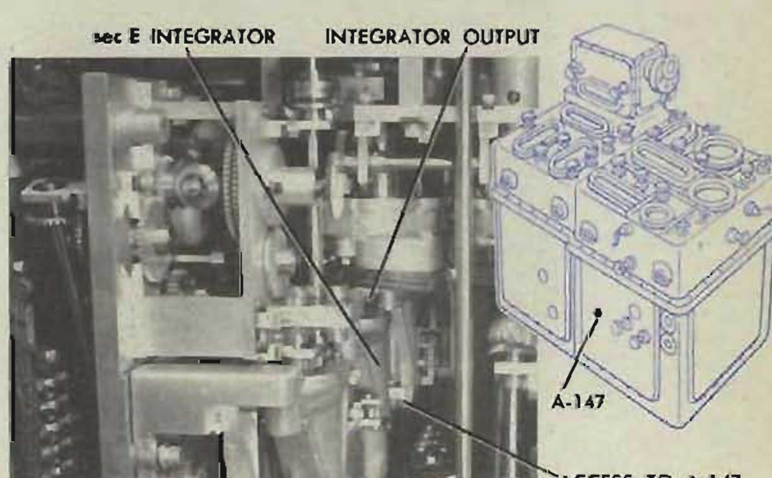


A-147 SECANT E INTEGRATOR to SECANT E CAM

Location

A-147 is under cover 3, 16 inches in, on the sec *E* integrator carriage.

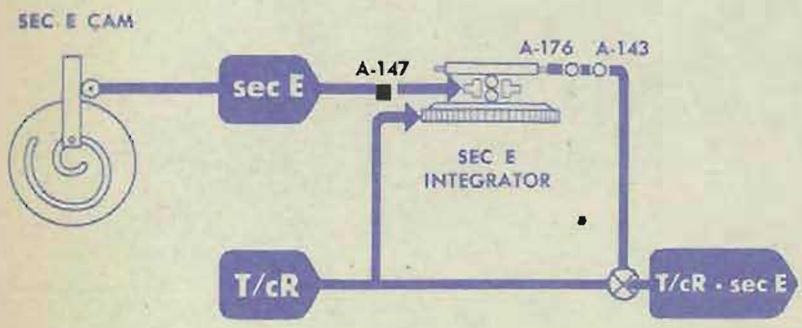
A-147 is a vernier adjustment screw.



Check

Set *E* at 60° 49′. The sec *E* integrator carriage should be at the center of the disk.

Turn the power ON.
Turn the time motor ON.



There should be no integrator roller output while the disk is turning.

Adjustment

If there is any integrator roller output, loosen the locking screw and turn the A-147 vernier adjustment screw until there is no output.

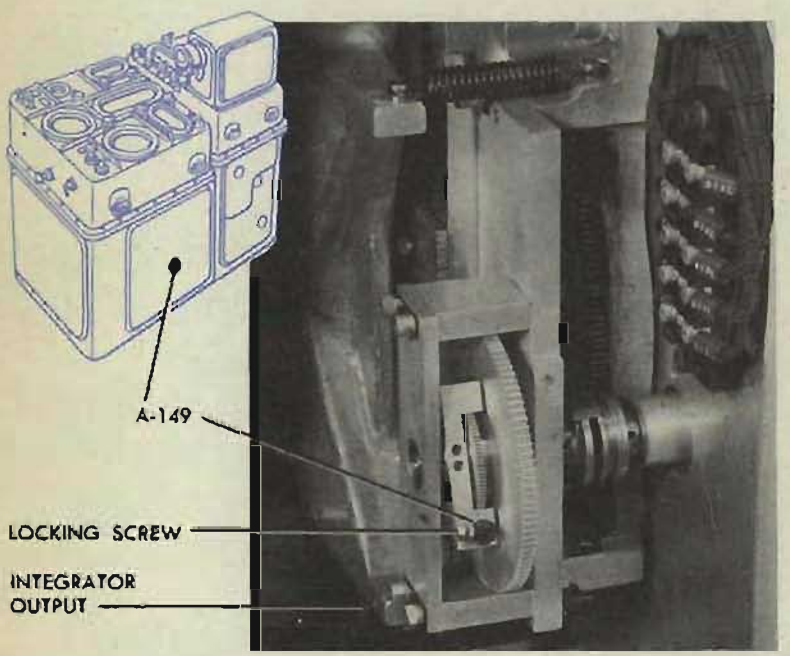
Tighten the locking screw and re-check.

Note

This is a preliminary adjustment. To refine the adjustment, run the *T/cR* · sec *E* unit check test. See page 215.

Recheck by running the bearing B tests.

A-149 and A-150 1/cR INTEGRATOR to 1/cR CAM



Location

A-149 and A-150 are under cover 5, on the carriage input to the 1/*cR* integrator.

A-149 is the vernier adjustment screw. A-150 is the coarse adjustment clamp.

Note

A-150 is omitted on instruments with Ser. Nos. 221 and higher.

Check

Set *cR* at 2790 yards by turning the *jR* handcrank. The 1/*cR* integrator carriage should be at the center of the disk.
Turn the power ON.

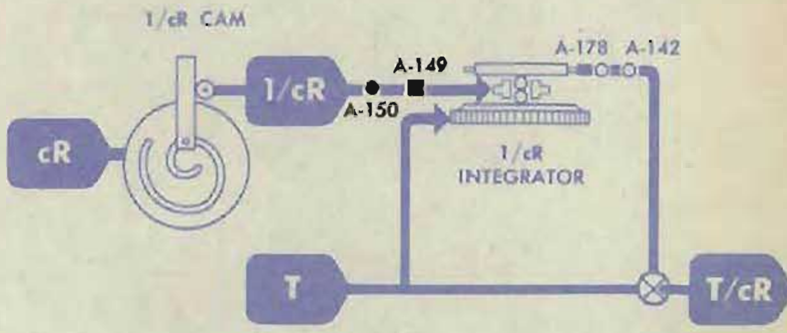
Set *dR* at 0 with the handcrank IN.
Turn the time motor ON.
There should be no integrator roller output while the disk is turning.

Adjustment

If there is any integrator roller output, loosen the locking screw and turn the A-149 vernier adjustment screw until there is no output. The integrator carriage is now at the center of the disk.

Tighten the locking screw and recheck.

In the older instruments which have A-150, check whether A-150 is loose. If A-150 is loose, push the integrator to the center of the disk, and tighten the clamp. Then adjust A-149.



Note

This is a preliminary adjustment. To refine the adjustment, run the *T/cR* unit check test. See page 212.

Recheck by running the elevation and bearing B tests.

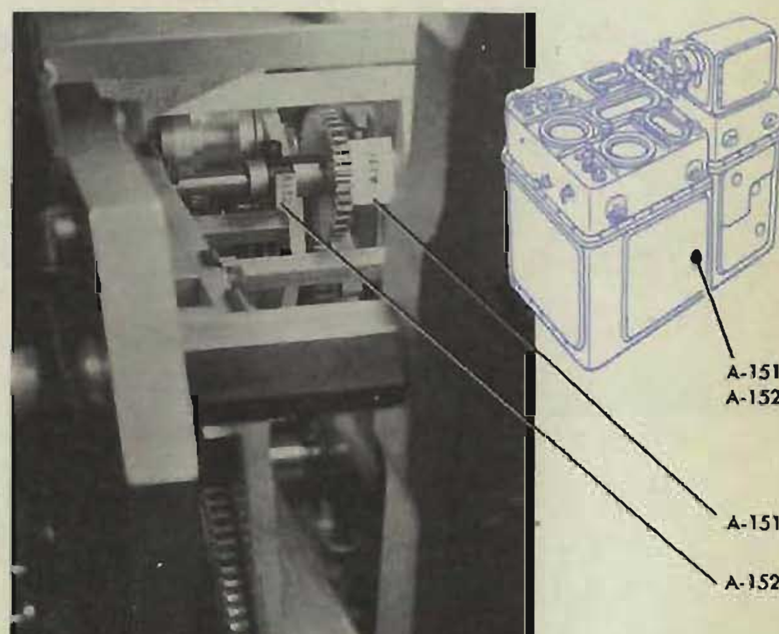
A-151 and A-152 1/cR CAM to cR DIALS

Location

A-151 and A-152 are under cover 5, to the right of the *cR* intermittent drive.

A-151 is the vernier adjustment screw.

A-152 is the coarse adjustment clamp.



Check

Set *cR* above 1500 yards.

Decrease it steadily until the 1/*cR* cam follower just *ceases* to move.

This is the start of the outer constant radius of the cam.

Motion of the follower can be observed on the three-inch spur gear toward the front of the 1/*cR* cam.

The cam should be positioned so that further movement does not move the cam follower.

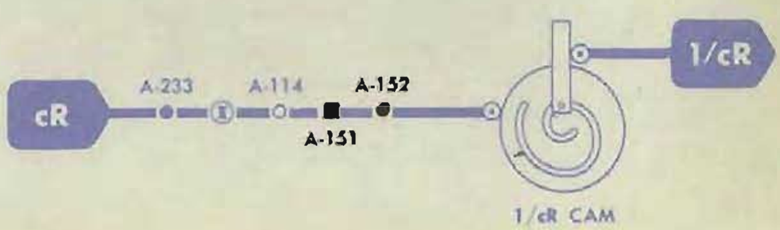
Note the reading of the *cR* dials.

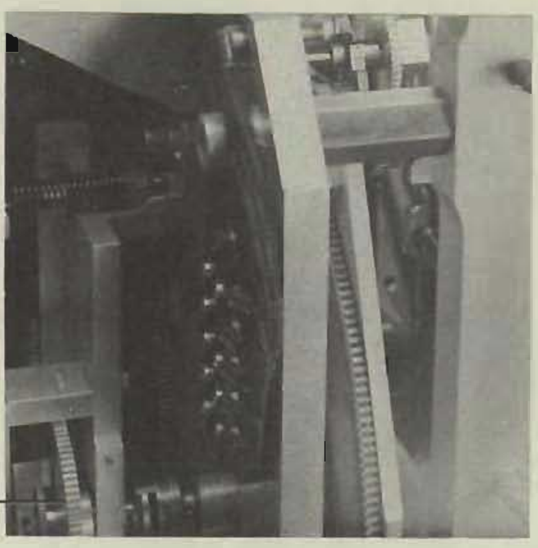
Decrease *cR* to 0.

Increase *cR* steadily until the follower just starts to move.

Note the reading of the *cR* dials.

The average reading should be 1500 yards.





SPUR GEAR

Adjustment

If the average reading of *cR* is not 1500 yards, check A-152. If it is loose, set *cR* at exactly 1500 yards and move the cam by hand until the follower just starts to move. Tighten A-152.

If A-152 is tight and the average reading is not 1500 yards, loosen the A-151 locking screw and turn the A-151 vernier adjustment screw until the average reading is correct. Then tighten the locking screw and recheck.

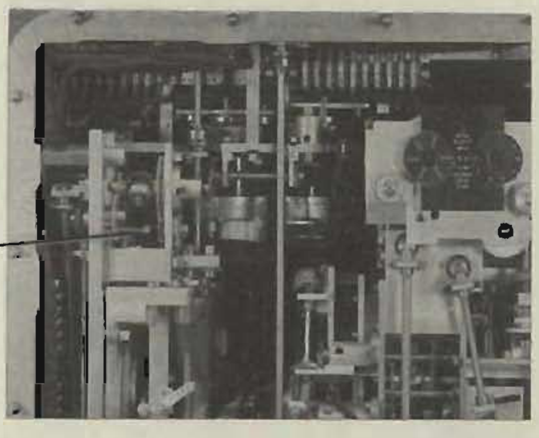
Check A-149.

Note

This is a preliminary adjustment. To refine the adjustment, run the *T/cR* unit check test. See page 212.

Recheck by running the bearing and elevation B tests.

A-153 ASSEMBLY CLAMP



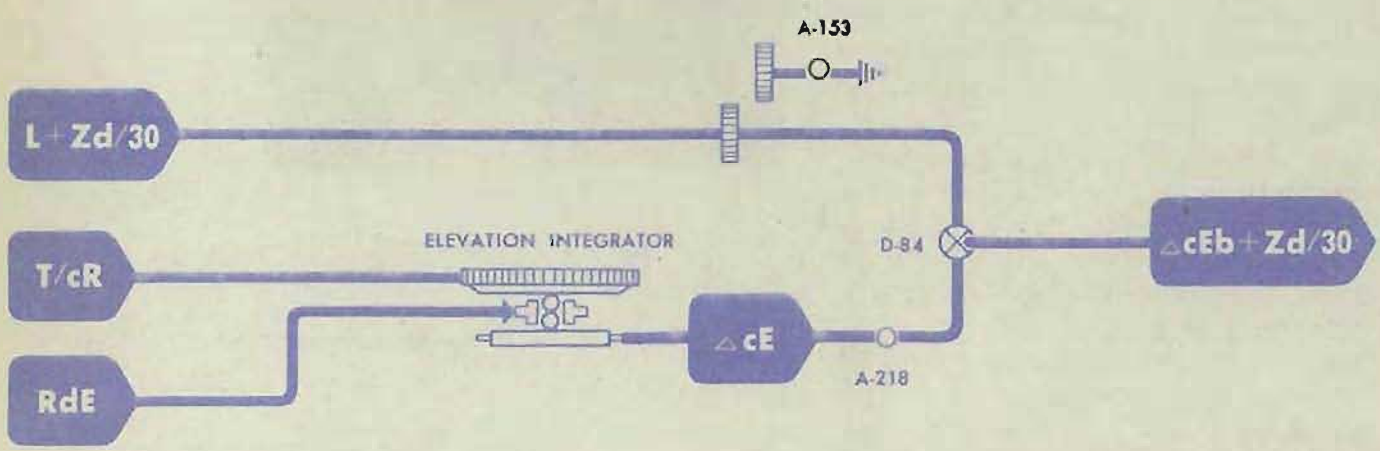
A-153

Location

A-153 is under cover 3, at the upper left.

Check

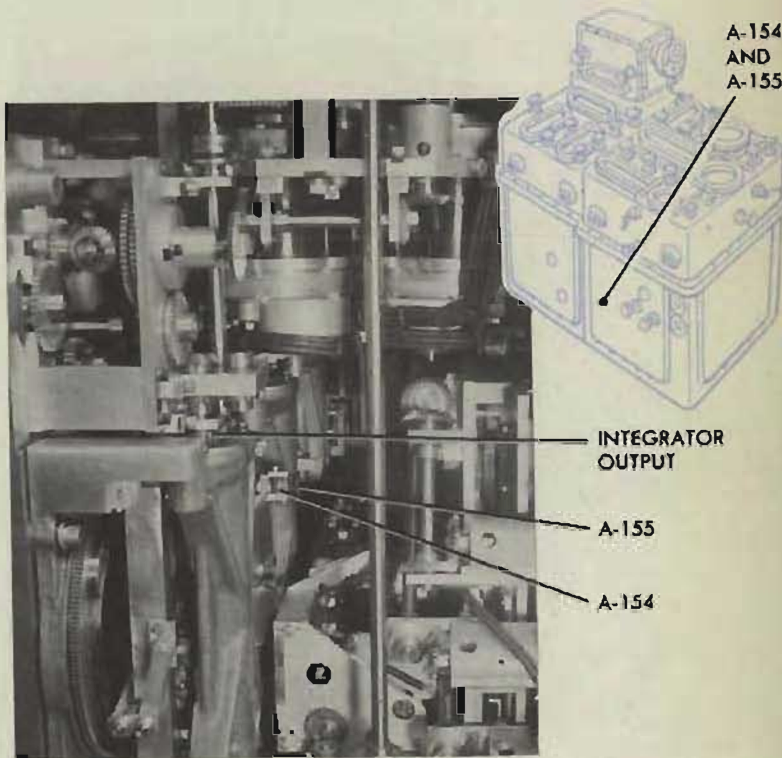
On all computers other than Mod 0, A-153 should be tightened *out of mesh*. On Mod 0 it should be tightened when the gear on which it is mounted is *in mesh* with D-84.



A-154 and A-155 ELEVATION INTEGRATOR to RdE LINE

Location

A-154 and A-155 are under cover 3. A-154 is the vernier adjustment screw. A-155 is the coarse adjustment clamp.



Check

Turn the power ON.

Set *dH*, *Sh*, and *So* at 0 knots. The *RdE* line is now at its zero position.

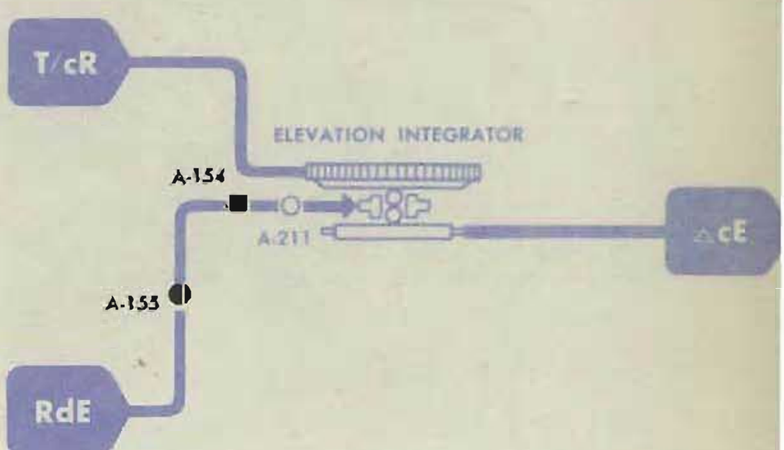
The elevation integrator carriage should be at the center of the disk. Set *cR* at 5000 yards. Turn the time motor ON. There should be no integrator roller output while the disk is turning.

Adjustment

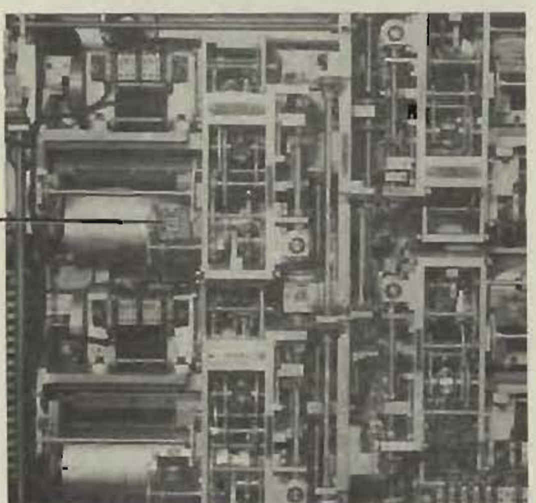
If there is any movement of the integrator output roller, loosen A-155, and push the carriage of the integrator to the approximate center of the disk. Tighten A-155. Then loosen the locking screw of A-154 and turn the vernier adjustment screw until there is no roller output.

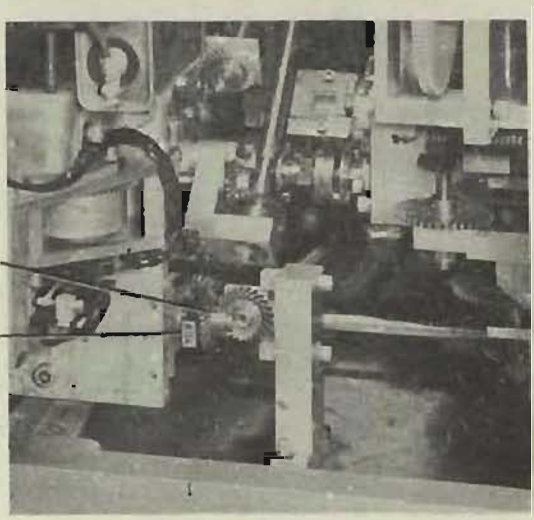
Tighten the locking screw, and recheck by bringing *dH* on zero from both directions and splitting any error.

Recheck by running the elevation B tests.



A-156 PARALLAX COMPONENT SOLVER to R2 COUNTER





Location

A-156 is under cover 5, at the lower right of the *R2* follow-up.

Check

Set *B'gr* and *B'r* at 90°.
Set *E2* at 0°. Use the sync *E* hand-crank in the CENTER position.

Set *L* at 2000' on the computer dials. Set the *R2* counter of the *Tf* ballistic computer at 1560 yards and wedge the line.

The *Ph* dial should read 3°40' RIGHT.

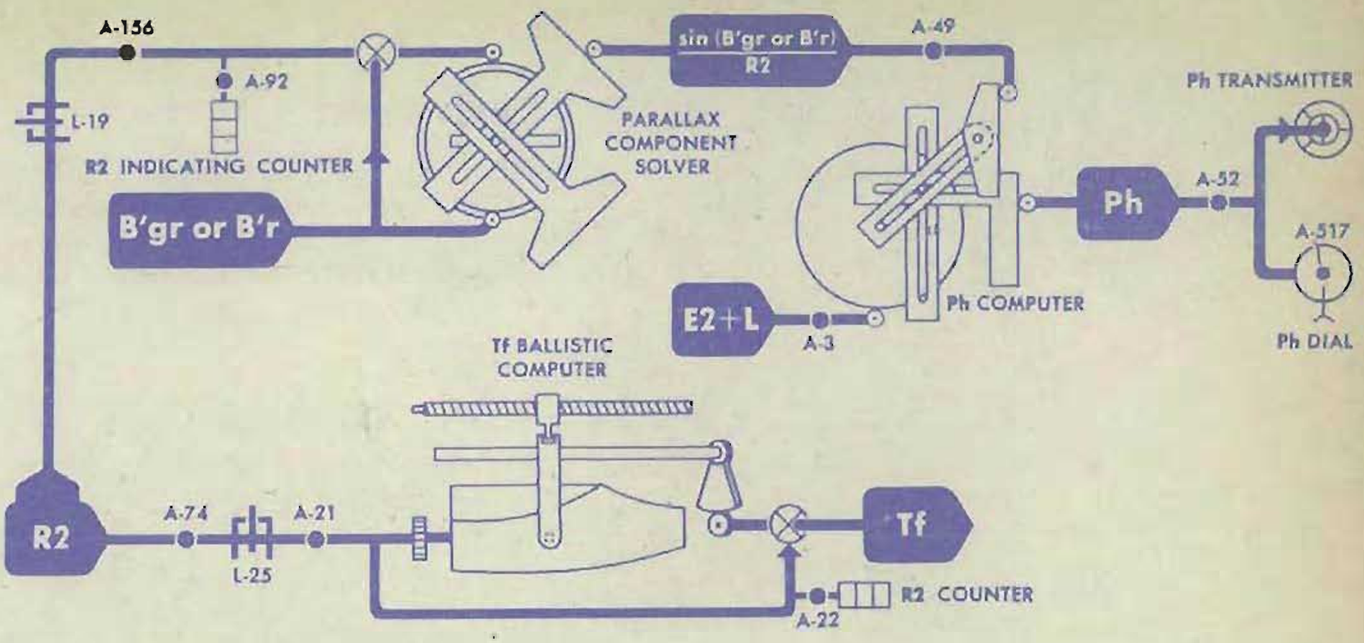
Adjustment

If the *Ph* dial does not read 3°40' RIGHT, make A-156 slip-tight. Slipping through A-156, turn the bevel gear at the right of the clamp until the dial reading is correct. Split any lost motion.

Tighten A-156, and recheck.
With *B'gr* and *B'r* at 270°, the *Ph* dial should read 3°40' LEFT.

Readjust A-3.
Remove wedges.
Readjust A-92.

Table of Contents

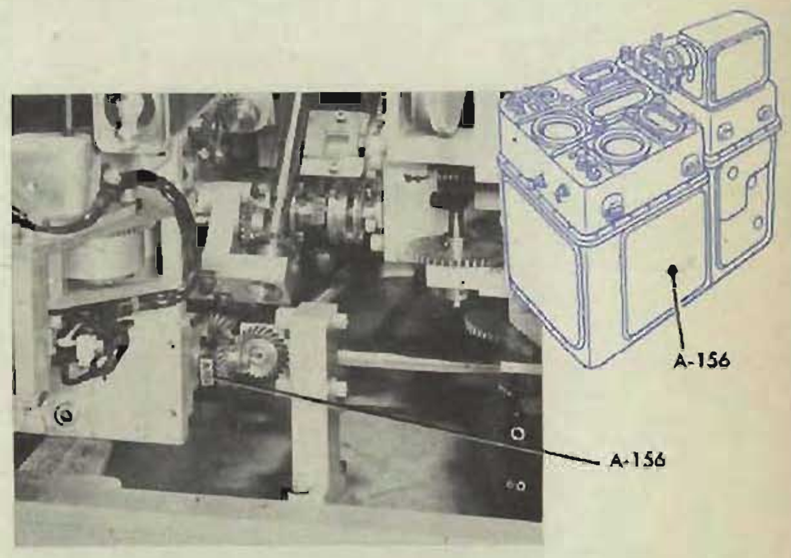


A-156 R2 INTERMITTENT DRIVE to R2 COUNTER (Mods 8 and 12)

Location

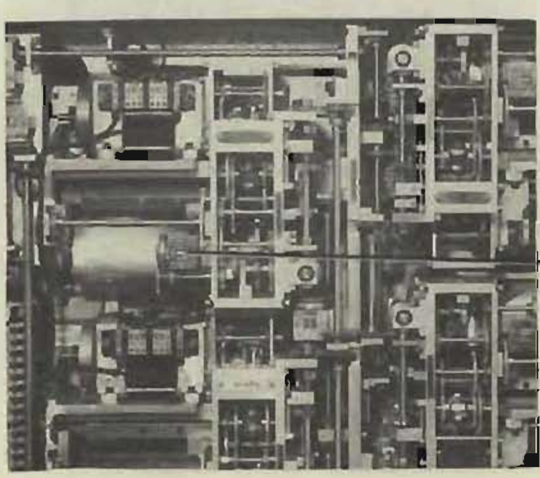
A-156 is under cover 5, at the lower right of the *R2* follow-up.

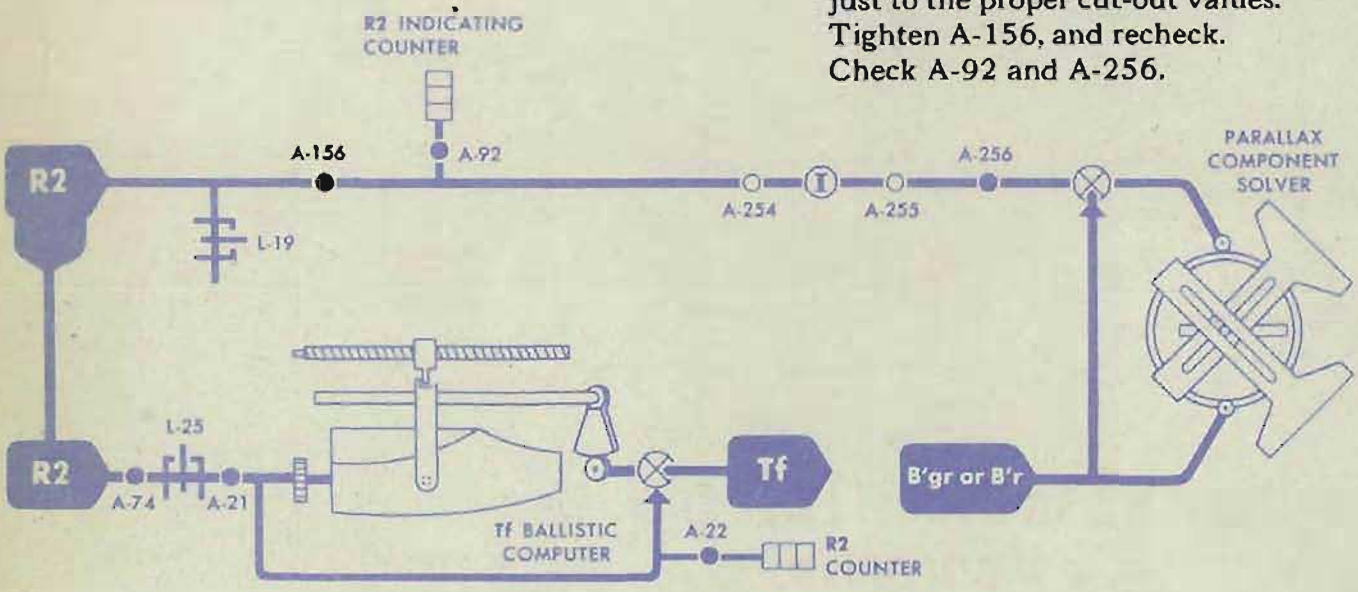
The *R2* intermittent drive is under cover 7, behind the left side of the lower right terminal block.



Check

The *R2* intermittent drive should have its cut-out points at 1500 and 18,900 yards.

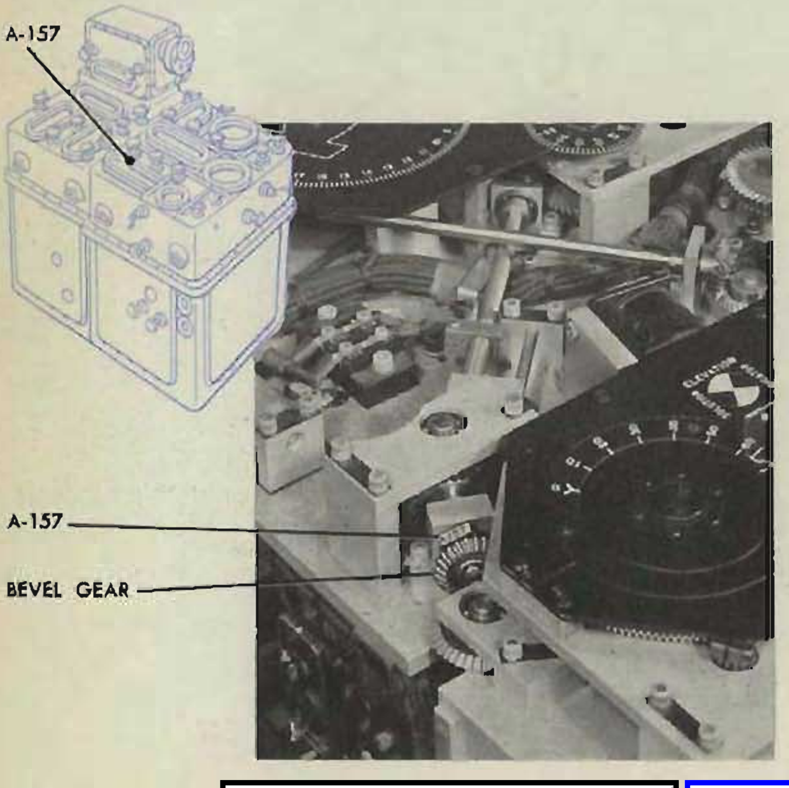




Adjustment

If the cut-out points are not 1500 and 18,900 yards, loosen A-156 and adjust to the proper cut-out values. Tighten A-156, and recheck. Check A-92 and A-256.

A-157 HORIZONTAL WIND COMPONENT SOLVER to Sw DIAL



Location

A-157 is under cover 1, to the left of the *Sw* input gear.

Check

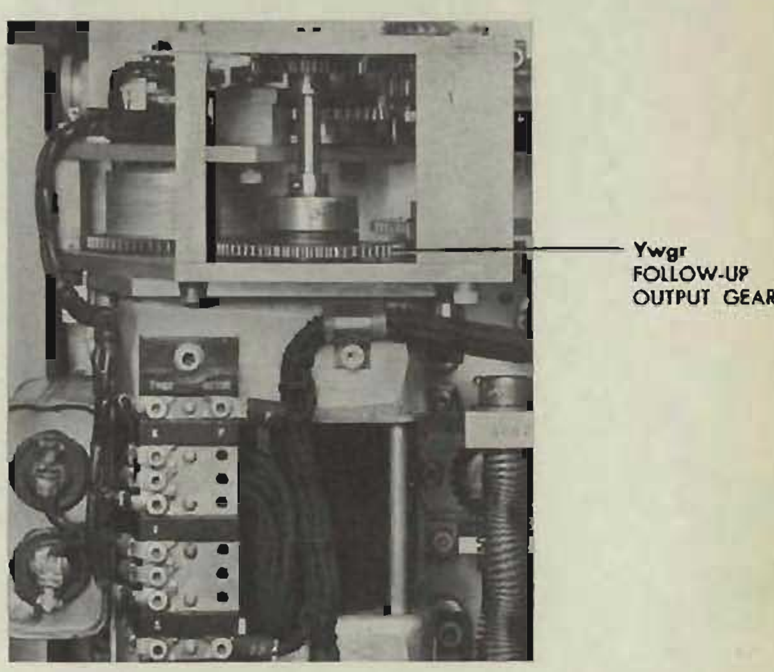
Turn the power ON.

Set *B* at 0°.
Set *Ds* at 500 mils.
Set *Sw* at 0 knots.
Set *Bw* at 90°.

Mark the *Ywgr* follow-up output gearing for use as an indicator.

Turn the *Bw* input gear until *Bw* reads 0°.
The output racks of the horizontal wind component solver should not move.

Movement of the *Ywg* output rack can be checked by observing the marks on the *Ywgr* follow-up output gear.



Adjustment

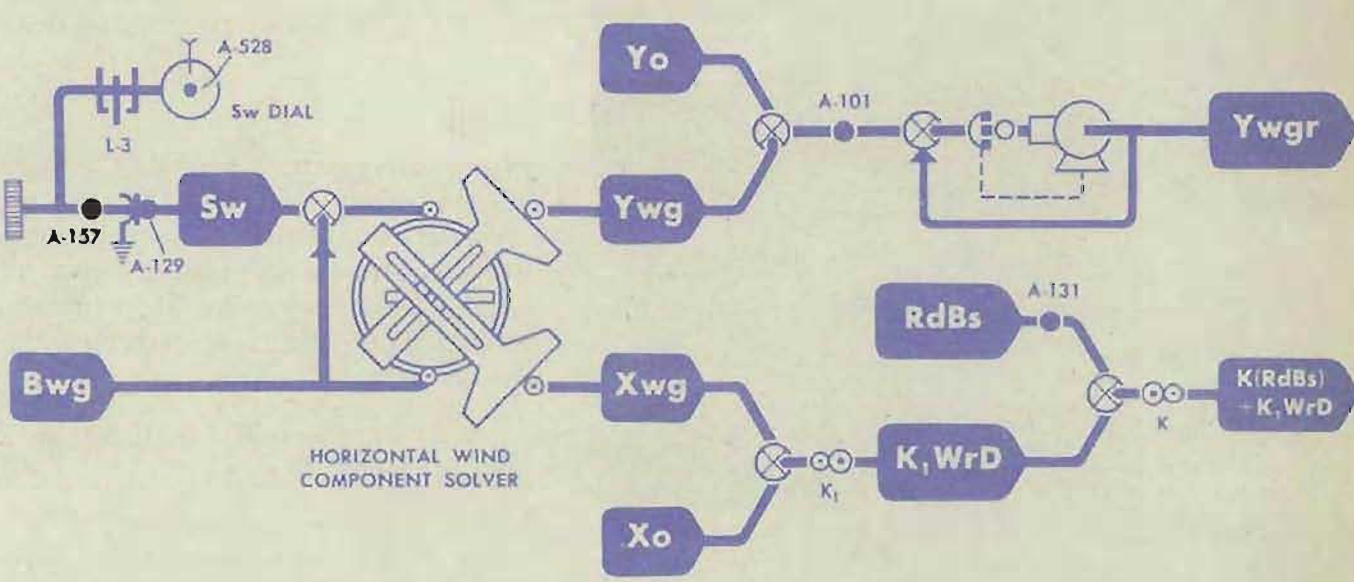
If there is any output, make A-157 slip-tight.
Set *Sw* at 0 knots, and *Bw* at 0°.
Turn the bevel gear at the rear of the clamp until the *Ywgr* indicating marks match.

Tighten A-157.

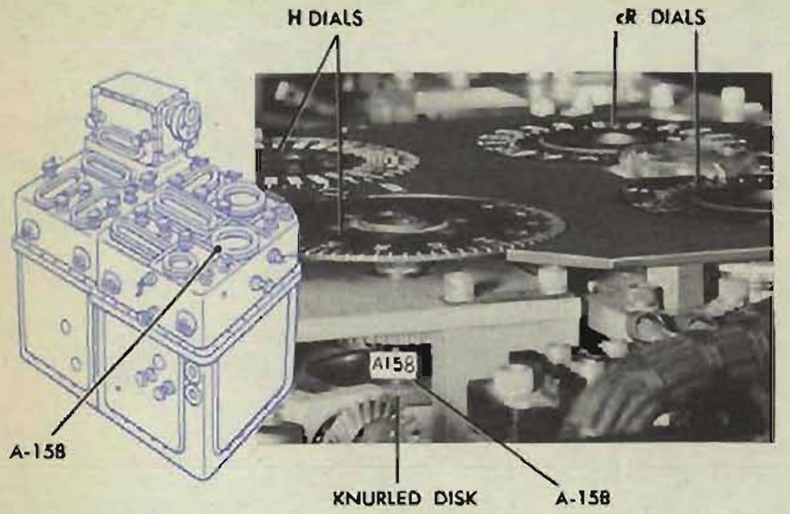
Recheck

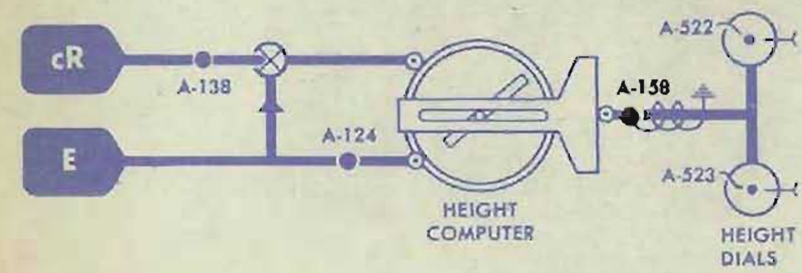
Set *Sw* at 0 knots.
Turn *Bw* through 360°.
The output gearing of the *Ywgr* follow-up should not move more than one tooth.

Check A-101, A-131 and A-229.



A-158 TAKE-UP SPRING ON HEIGHT LINE





Location

A-158 is under cover 1, below the coarse *H* dial.

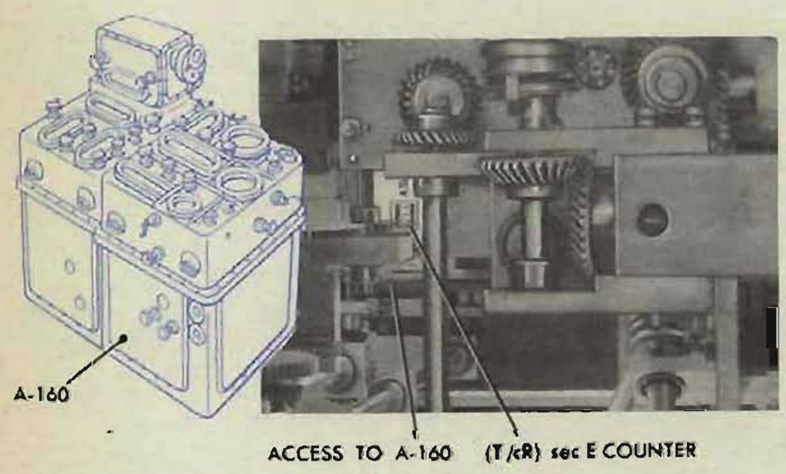
The spring should always have sufficient tension to remove the lost motion from the mechanisms driving the *H* dials.

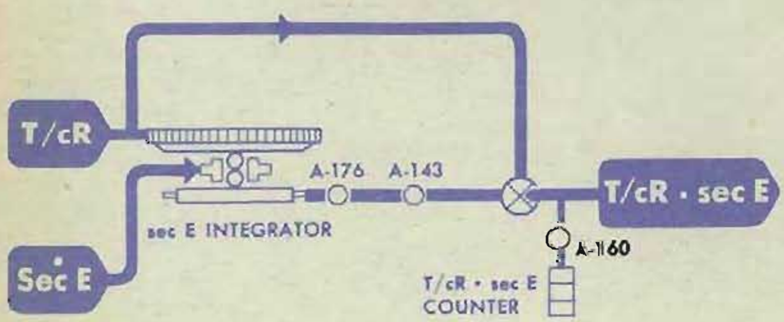
Adjustment

Set *E* at its lower limit.
Set *cR* at its upper limit.
Slip-tighten A-158. Turn the knurled disk below the clamp clockwise until the spring is fully wound.
Tighten A-158.

Check A-522, A-523, and A-124.

A-160 ASSEMBLY CLAMP





Location

A-160 is under cover 3, on the gear meshing with the (T/cR) sec E counter. On later instruments, the gear on which A-160 is mounted may be slid out of mesh with the counter gear.

Check

If a sliding gear is provided, A-160 should be tightened with the gear out of mesh except while timing the integrators. Then it must be tightened in mesh. On the earlier instruments, A-160 should be tightened with the gears meshed.

Adjustment

Readjust A-160 according to the check. No further adjustment is necessary.

A-161 FRICTION DRIVE ON TIME MOTOR REGULATOR

Location

A-161 is under cover 1, at the right front, on the input gear of the time motor regulator.

Check

Turn the power OFF.

Disconnect leads TM2 and TMR from the regulator, loosen the three screws holding the unit, and remove it from the computer.

Check the friction by turning the input gear. The friction should be tight enough to drive the regulator when the gear is turned counterclockwise as viewed from the bottom. It should be loose enough, however, to slip easily when the gear is turned in the opposite direction.

Adjustment

If the friction is not adjusted properly, loosen A-161 and turn the clamp to vary the friction as required.

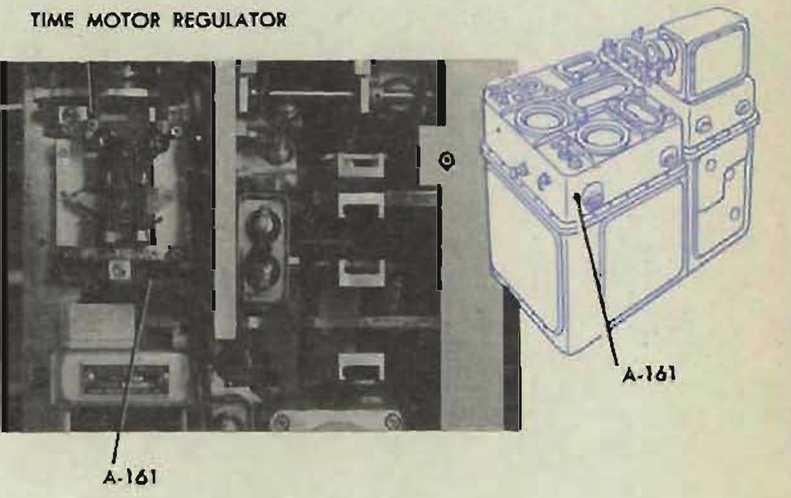
Tighten the screw and recheck.

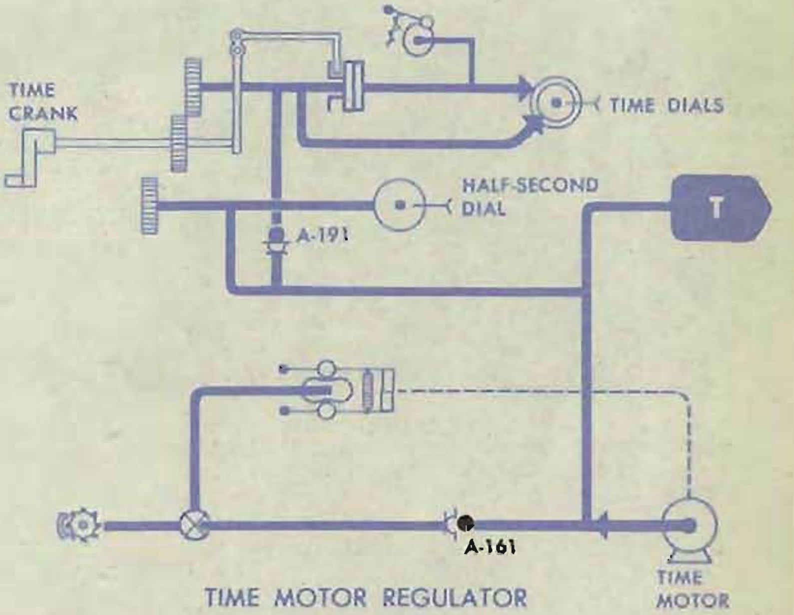
Replace the regulator in the computer, and check that the gears mesh properly and that the regulator input gear has sufficient side clearance.

CAUTION

If this friction is too tight, turning the time crank counterclockwise in the OUT position will damage the regulator mechanism.

TIME MOTOR REGULATOR





TIME MOTOR REGULATOR

A-162 TIME FRICTION DRIVE

Note

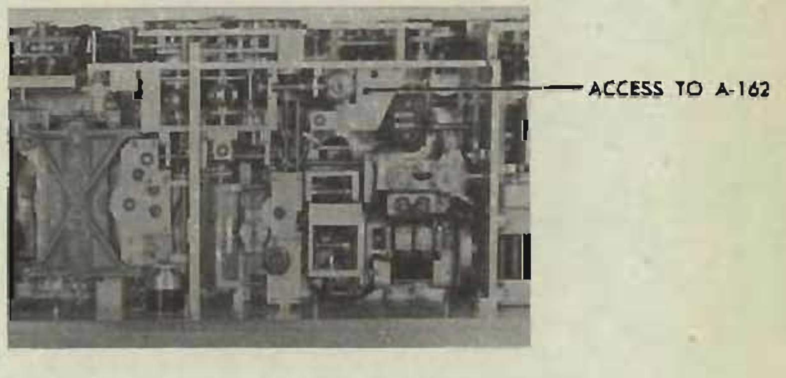
A-162 does not exist on instruments with Ser. Nos. 101 and higher. A-162 was made inoperative on Ser. Nos. 100 and lower by OD 4185.

Location

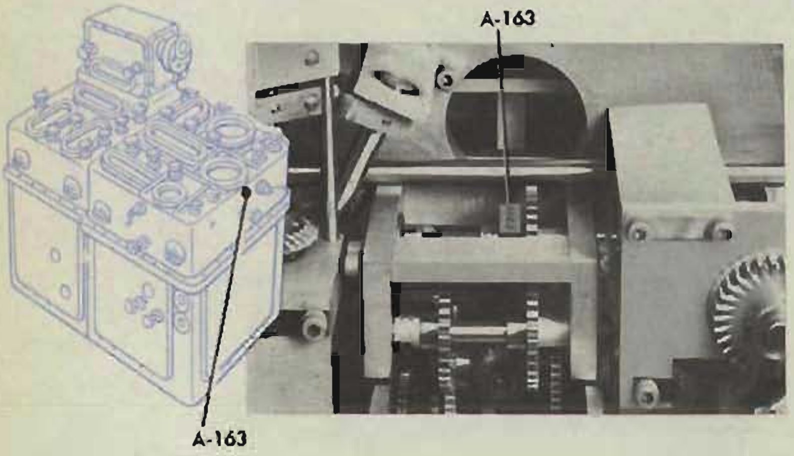
A-162 is under cover 1, at the front.

Adjustment

Tighten the screw on A-162, leaving the friction loose.



A-163 SYNCHRONIZING THE dR FOLLOW-UP



Location

A-163 is under cover 1, on the input gearing of the *dR* follow-up.

CAUTION

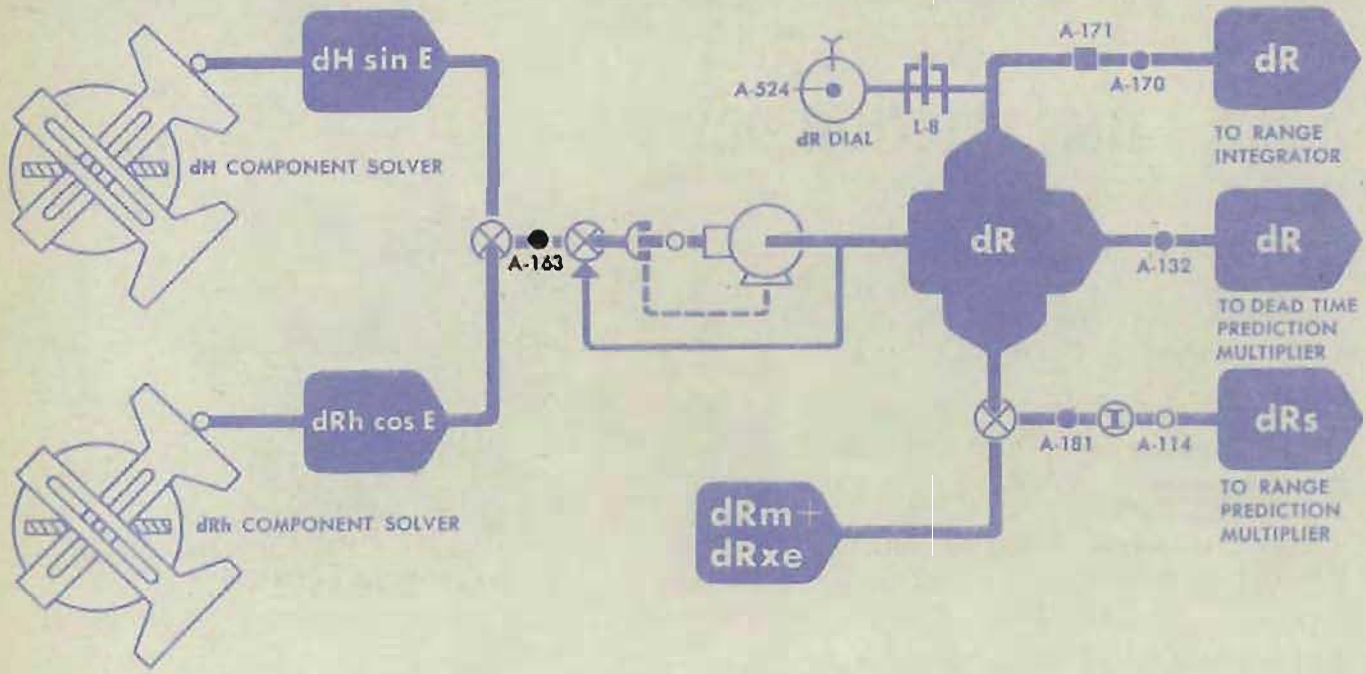
With the power OFF, turn the *dR* follow-up output manually from limit to limit. If any restriction is felt, A-170, A-132, or A-135 may be upset. Determine the cause of the restriction, and loosen the clamp causing it.

Check

Remove the KRR lead on the target angle switch.
Turn the power ON.
Set *So*, *Sh*, and *dH* at 0 knots.
Set *Br* at 270°.
Set *A* at 90°.
Wedge all lines.
The *dR* dial should read 0 knots.

Adjustment

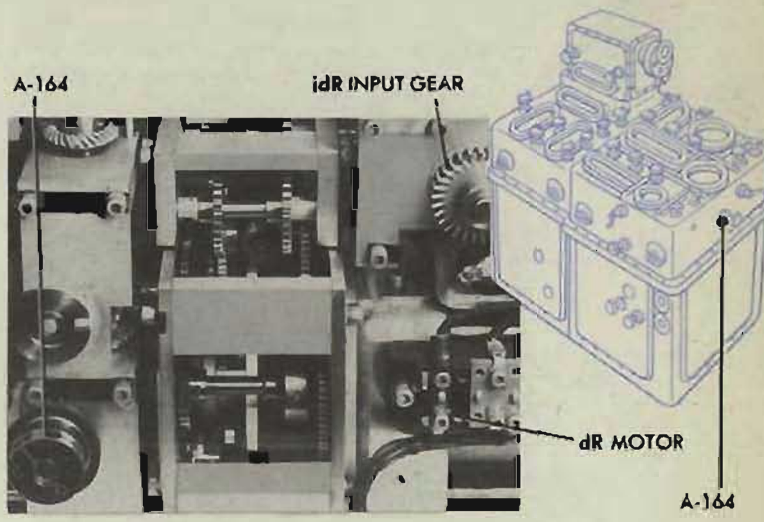
If the *dR* dial does not read 0 knots, slip-tighten A-163. Turn the spur gear to the right of A-163 until the follow-up motor synchronizes with the *dR* dial at 0 knots.
Tighten A-163, and recheck.
Remove all wedges. Replace the KRR lead.
Readjust any loosened clamps.
Check A-171, A-132, and A-181.



A-164 jdR HOLDING FRICTION

Location

A-164 is located under cover 1, at the front center.



Check

This friction should be tight enough to prevent *jR* from backing out *jdR*, but not so tight as to overload the *jdR* motor during automatic range transmission.

Put the range correction integrator carriage in its uppermost position and wedge the range rate ratio line.

Turn *jR* to decrease *cR* to 0 yards.

The *jdR* friction should hold the *jdR* line motionless.

Run the synchronizing test of the range receiver, page 62.

Check that the *jdR* motor drives fast enough to synchronize within the prescribed time limit.

Adjustment

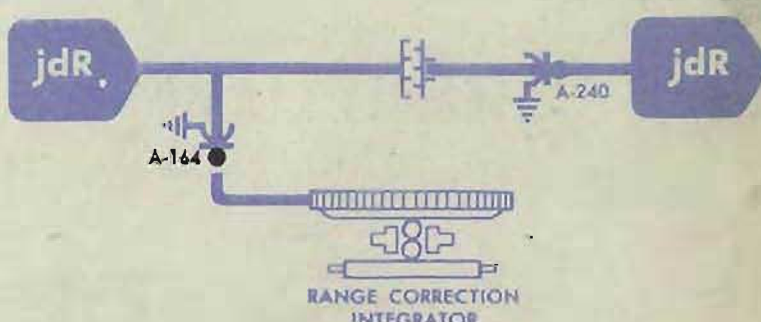
If both conditions under the check are not obtained, loosen A-164.

If the *jdR* line backs out, turn the clamp clockwise to increase the friction.

If the *jdR* motor drives too slowly, turn the clamp counterclockwise to decrease the friction.

Tighten A-164 and recheck.

Check A-240.



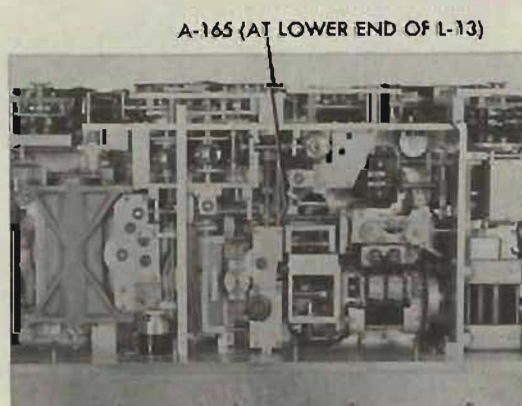
A-165 SPRING ON L-13

Note

A-165 does not exist on instruments with Ser. Nos. 101 and higher.

Location

A-165 is under cover 1, at the front.



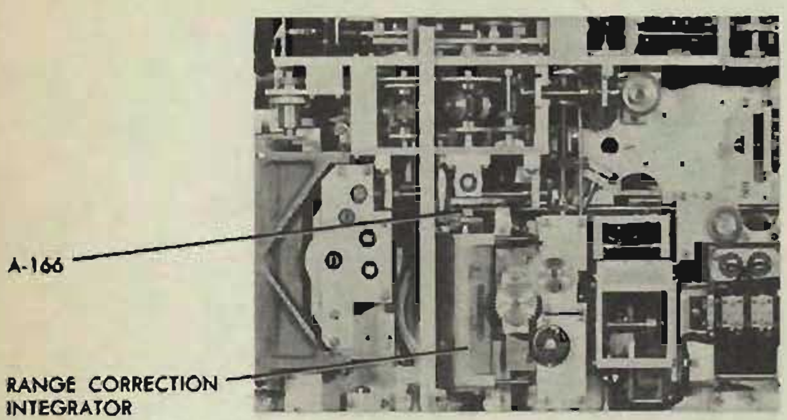
Check

A-165 should be tight enough to hold L-13 at the lower limit.

Adjustment

If A-165 does not hold L-13 at the lower limit, loosen the screw. Turn the clamp clockwise to tighten the spring. Tighten the screw and recheck.

A-166 ASSEMBLY CLAMP



Location

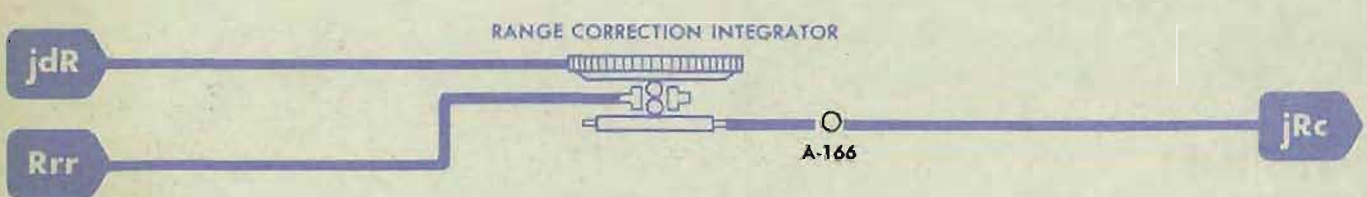
A-166 is under cover 1, at the front, on the output gear of the range correction integrator.

Check

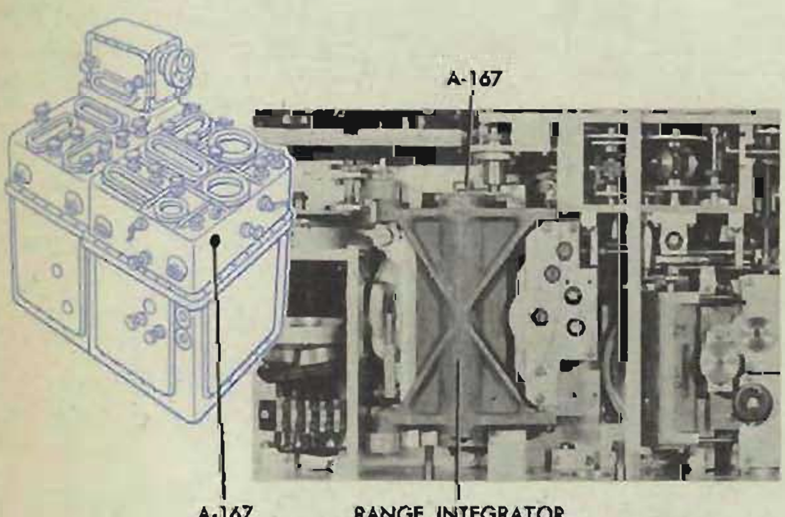
A-166 should be tight.

Adjustment

Tighten A-166. No further adjustment is necessary.



A-167 ASSEMBLY CLAMP



Location

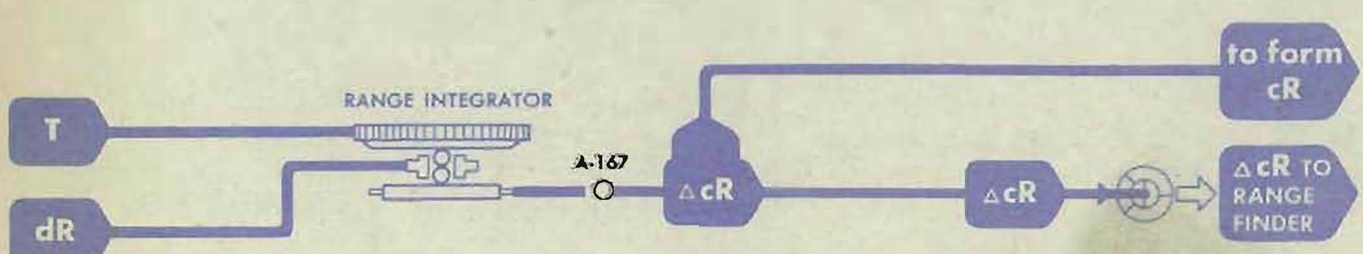
A-167 is under cover 1, at the front, on the output gear of the range integrator.

Check

A-167 should be tight.

Adjustment

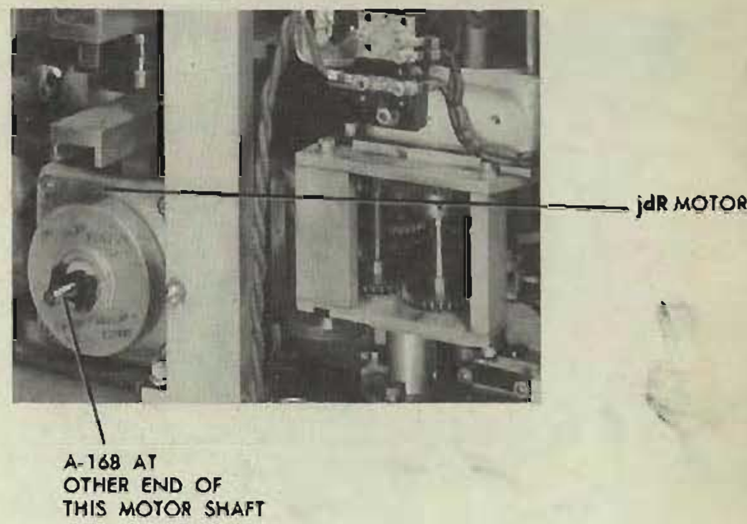
Tighten A-167. No further adjustment is necessary.



A-168 ASSEMBLY CLAMP

Location

A-168 is under cover 1, at the right front, on the pinion of the *jdR* motor. It can be reached only by removing the motor.



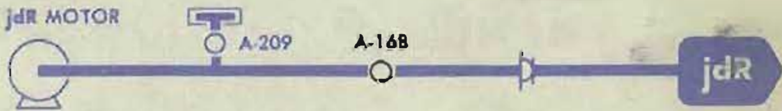
Check

If A-168 is loose, the energized servo may drive indefinitely, without turning the range line.

Adjustment

To remove the *jdR* servo motor, consult the section in this OP on removal of units.

Tighten A-168, and reinstall the *jdR* servo motor. No further adjustment is necessary.

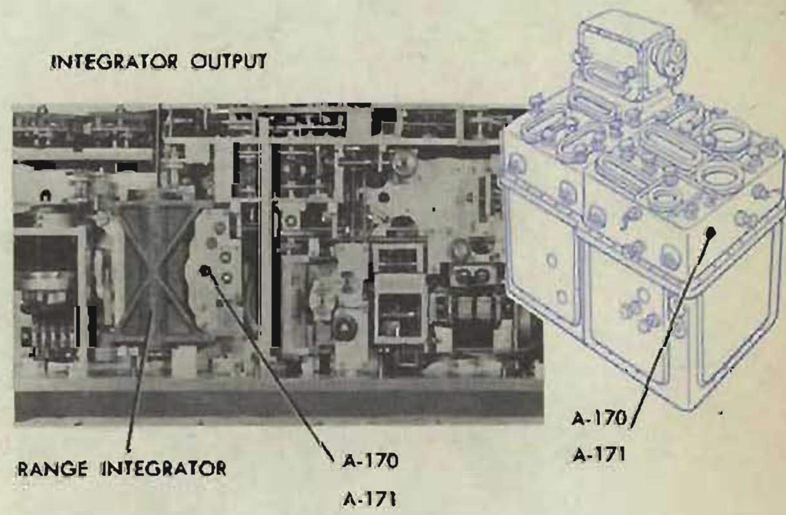


A-170 and A-171 RANGE INTEGRATOR to dR LINE

Location

A-170 and A-171 are under cover 1, behind the mounting plate to the right of the *dR* integrator.

A-170 is the coarse adjustment clamp. A-171 is the vernier adjustment.

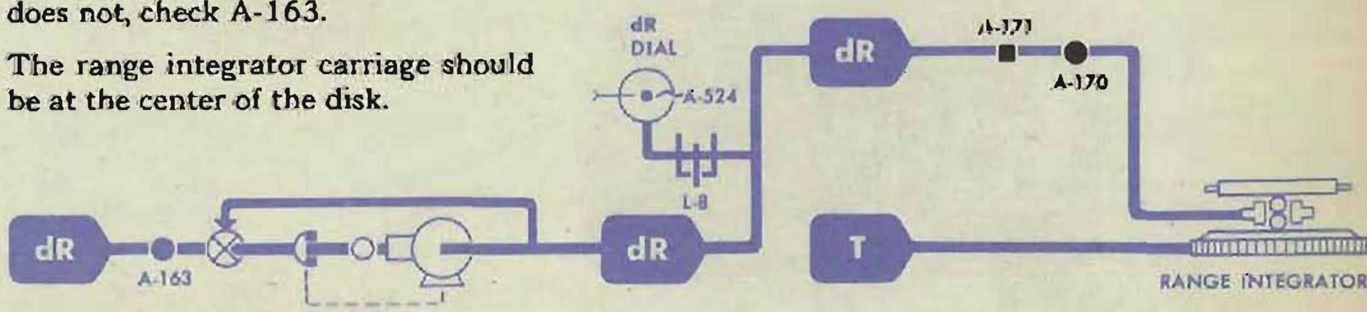


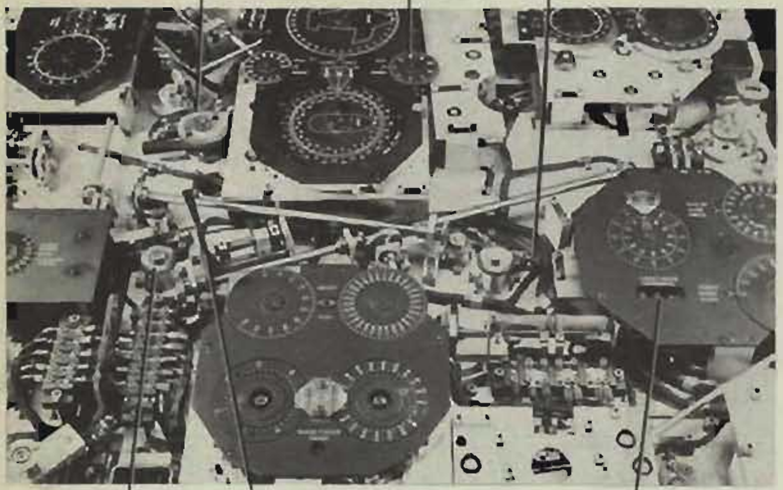
Check

Set *So*, *Sh*, and *dH* at 0 knots and wedge the lines.
Remove the KRR lead on the target angle switch.
Turn the power ON.

The *dR* line is now at its zero position, and the *dR* dial should read 0. If it does not, check A-163.

The range integrator carriage should be at the center of the disk.





Turn the time motor ON. There should be no output on the range integrator roller while the disk is turning.

Adjustment

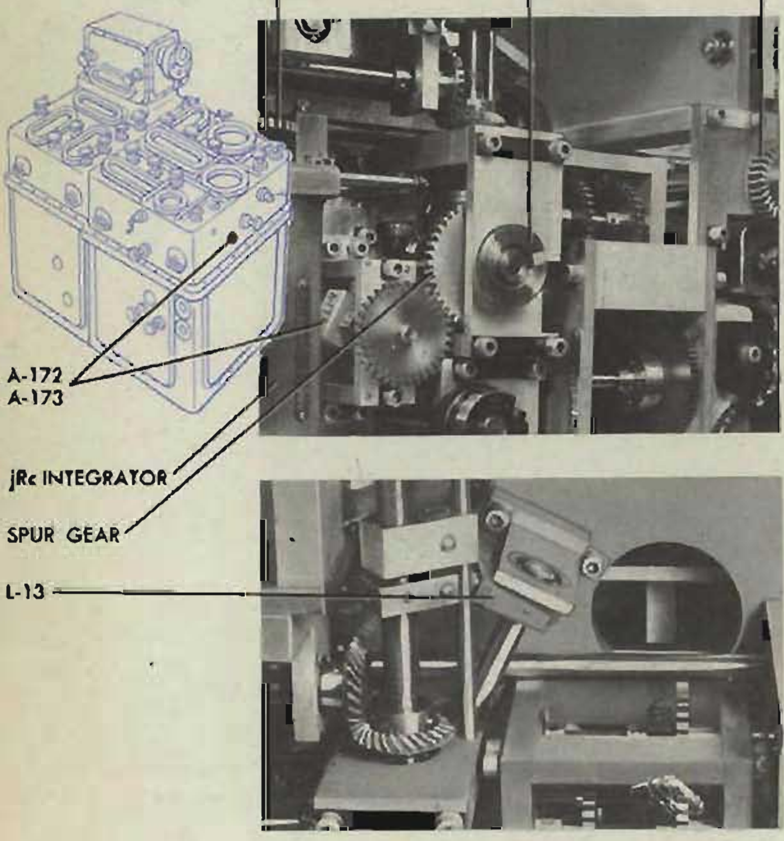
If there is any movement of the integrator roller, first check A-170. If it is loose, push the integrator carriage to the approximate center of the disk, and tighten A-170. Then loosen the locking screw on A-171 and turn the vernier adjustment screw until there is no output from the range integrator.

Tighten the locking screw and re-check.

Turn the time motor OFF. Remove the wedges. Replace the KRR lead.

Recheck by running the range B tests.

A-172 and A-173 RANGE CORRECTION INTEGRATOR to Rrr LINE



Location

A-172 and A-173 are under cover 1, at the front, on the carriage of the range correction integrator.

A-172 is the coarse adjustment clamp. A-173 is the vernier adjustment.

Limit stop L-13 is under cover 1, at the front. It consists of a metal block screwed to an arm. The arm is pinned to the upper end of a diagonal shaft on the range rate ratio input line. The shaft is to the left of the *dR* follow-up.

Check

This adjustment can be checked only with the range correction integrator carriage at its zero position. The block on the arm of the limit stop must be removed because it offsets the carriage from the zero position.
Remove the block.

Turn the large spur gear behind the *Rrr* knob coupling to bring the arm to its lower limit. The lower limit of the arm is to the left.

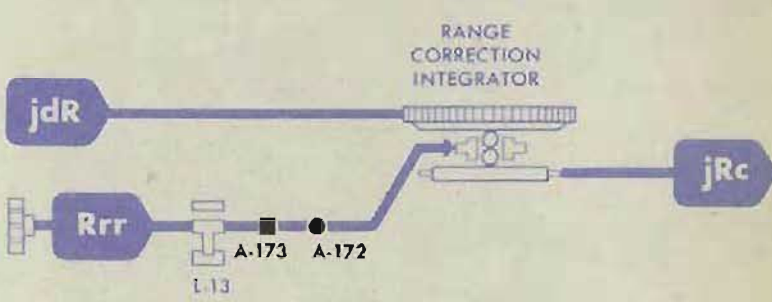
The integrator carriage should be at the center of the disk. Rapid turning of the *jdR* input gear should produce no motion of the output roller.

Adjustment

If there is any output from the integrator roller, the carriage is not at the center of the disk. Check whether A-172 is loose. If it is loose, push the integrator carriage to the center.

Tighten A-172.

Loosen the locking screw on A-173. Turn the vernier adjustment screw until there is no movement of the output roller when *jdR* is turned.



REMINDER

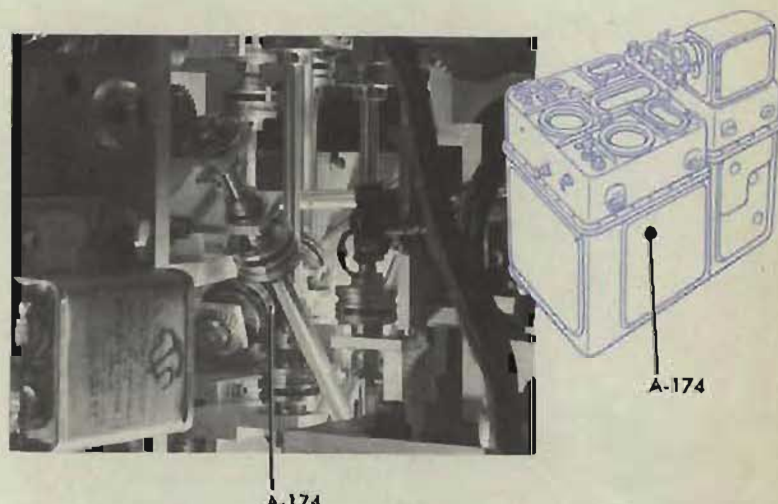
Tighten the vernier locking screw.

Replace the block on the stop arm, so that the integrator carriage cannot go to the zero position.

A-174 Rj HOLDING FRICTION

Location

A-174 is under cover 5, on a diagonal shaft.



Check

This friction should be tight enough to hold the *Rj* setting, but not so tight as to overload the *Rj* receiver motor.

Turn the generated range crank in the OUT position. *cR* should not back through the *Rj* line.

Run the *Rj* receiver synchronizing test, page 62. Check that the synchronizing time is within the allowable limits.

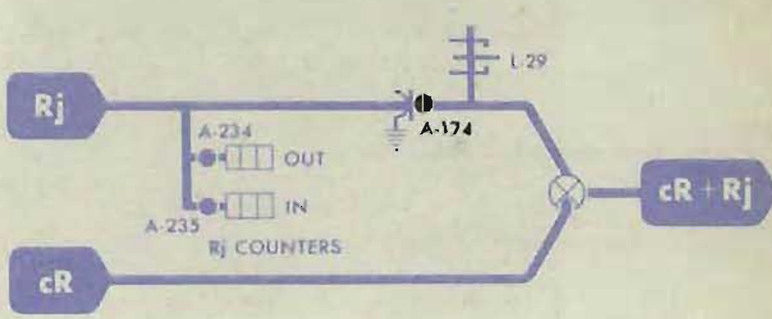
Adjustment

If both conditions under the check are not obtained, loosen A-174.

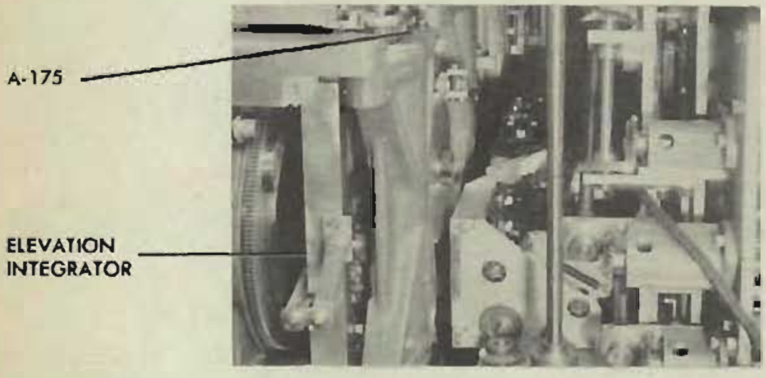
If the *Rj* line backs out, turn the clamp clockwise to increase the friction.

If the *Rj* receiver synchronizes too slowly, turn the clamp counterclockwise to decrease the friction.

Tighten A-174 and recheck.



A-175 ASSEMBLY CLAMP



Location

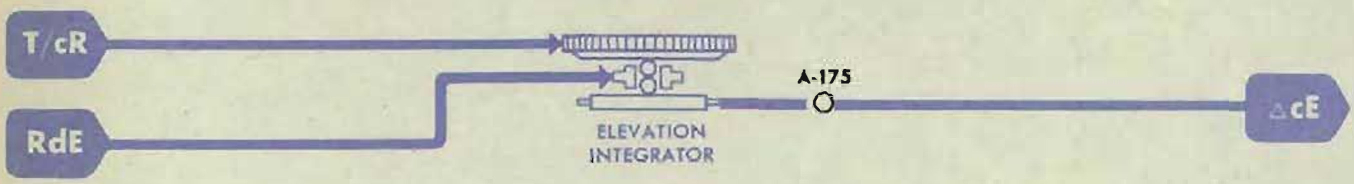
A-175 is under cover 3, on the output gear of the elevation integrator.

Check

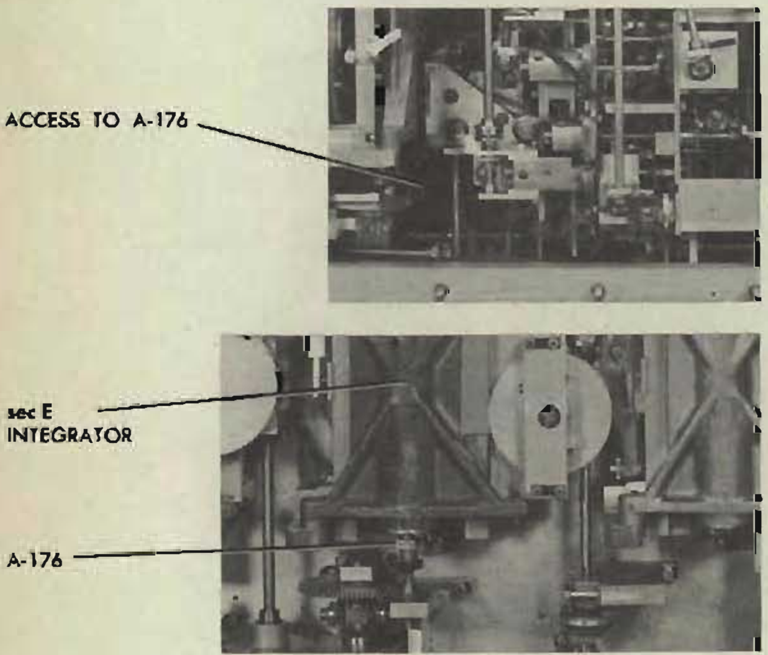
A-175 should be tight.

Adjustment

Tighten A-175. No further adjustment is necessary.



A-176 ASSEMBLY CLAMP



(INTEGRATOR ASSEMBLY REMOVED FROM INSTRUMENT)

Location

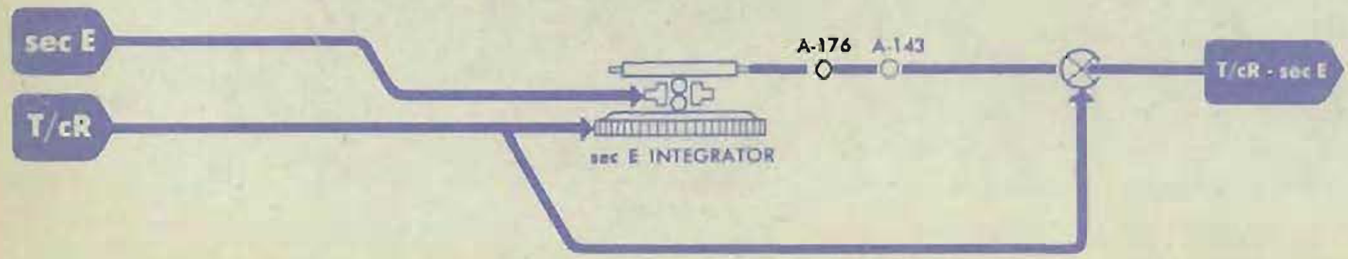
A-176 is under cover 3, on the output coupling of the sec *E* integrator.

Check

A-176 should be tight, and the coupling should be properly engaged.

Adjustment

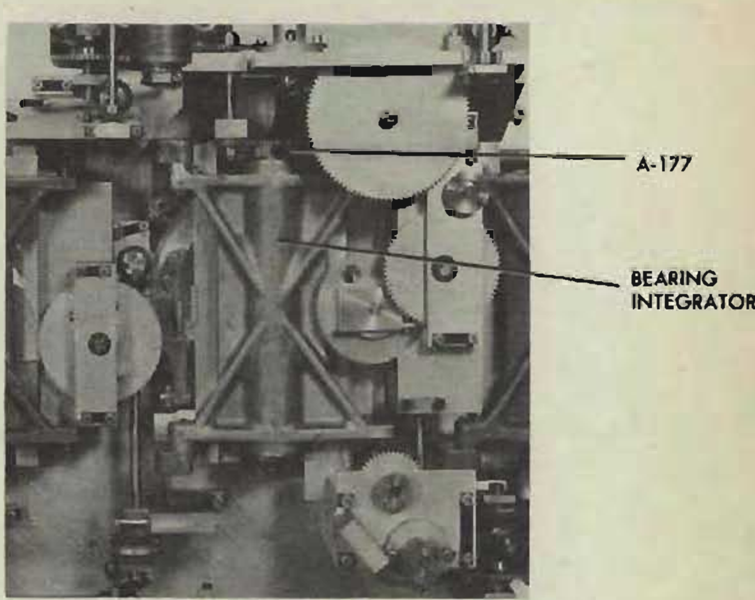
Tighten A-176. No further adjustment is necessary.



A-177 ASSEMBLY CLAMP

Location

A-177 is under cover 3, on the output gear of the bearing integrator.



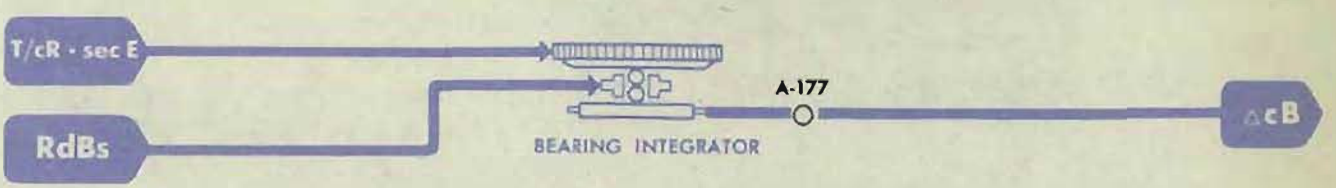
(INTEGRATOR ASSEMBLY REMOVED FROM INSTRUMENT)

Check

A-177 should be tight.

Adjustment

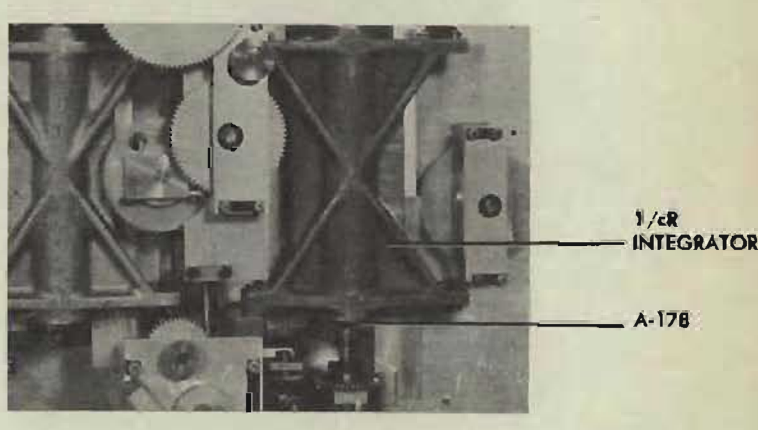
Tighten A-177. No further adjustment is necessary.



A-178 ASSEMBLY CLAMP

Location

A-178 is under cover 5, on the output coupling of the 1/*cR* integrator.

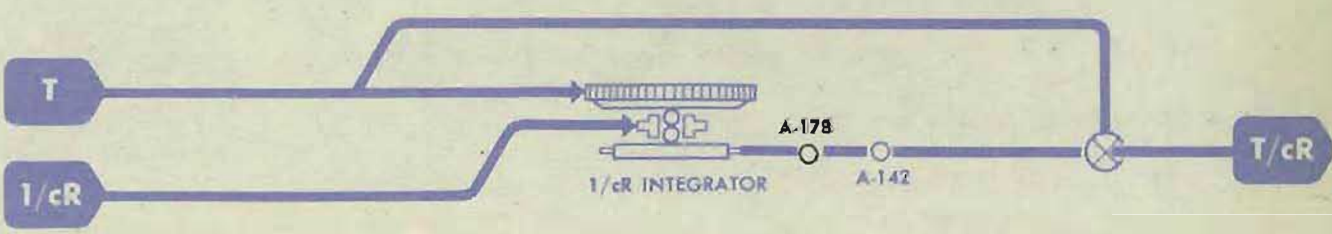


Check

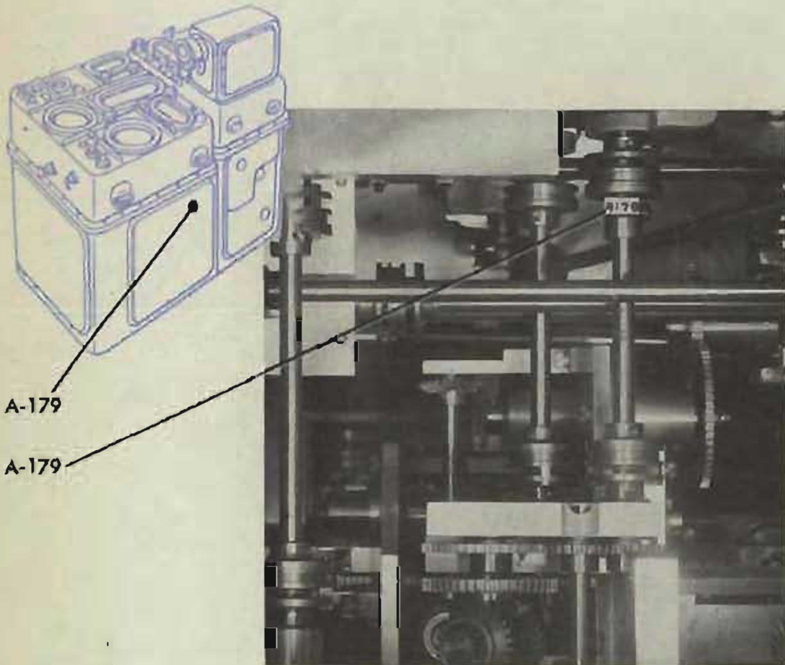
A-178 should be tight and the coupling should be properly engaged.

Adjustment

Tighten A-178. No further adjustment is necessary.



A-179 SHIP DIAL to Co RECEIVER



Location

A-179 is under cover 5, in the upper rear of the front section, below the coupling on a vertical shaft to the control unit.

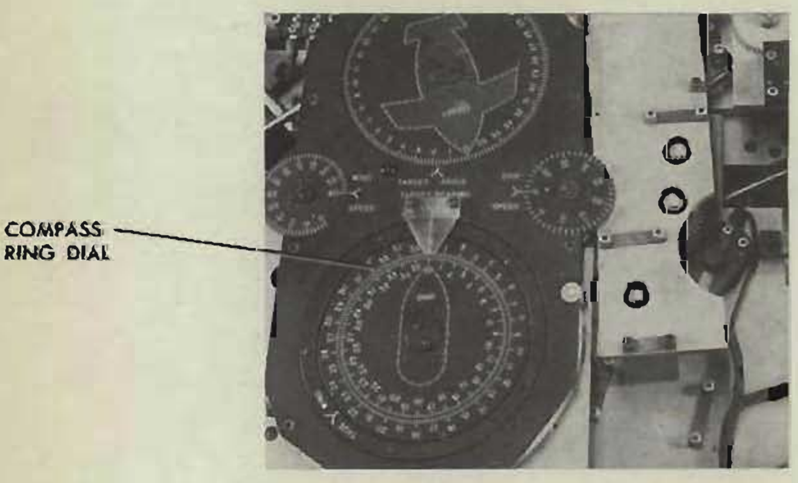
Check

Turn the power ON.

Put the *Co* handcrank in its OUT position.

Transmit *Co* from the gyro compass to the computer.

The reading of the ship dial against the compass ring dial should agree with the gyro compass reading.

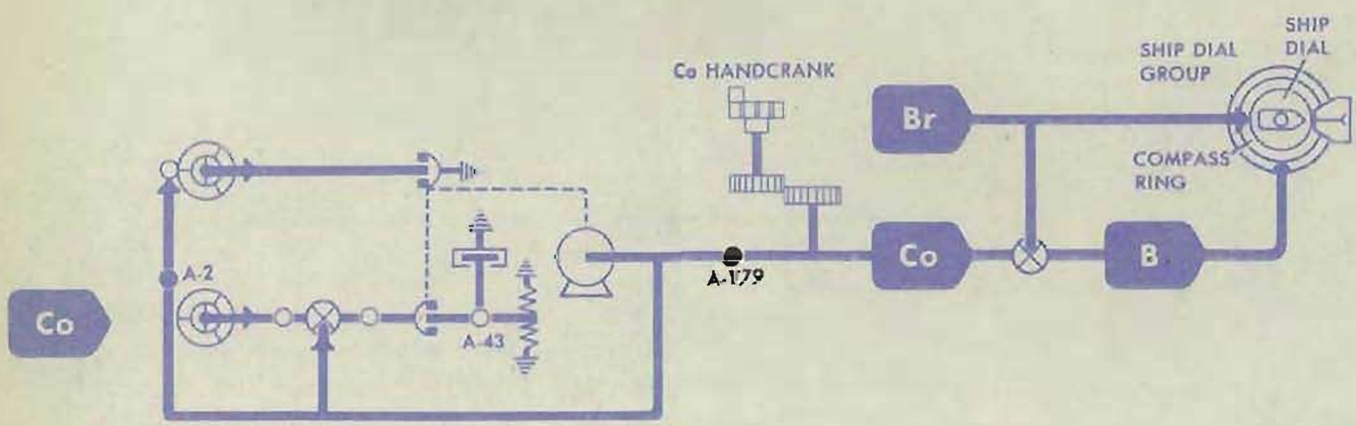


Adjustment

If the computer dial reading does not agree with the gyro compass reading, loosen A-179. Put the *Co* handcrank in its IN position and bring the compass ring dial to its correct value.

Return the *Co* handcrank to its OUT position.

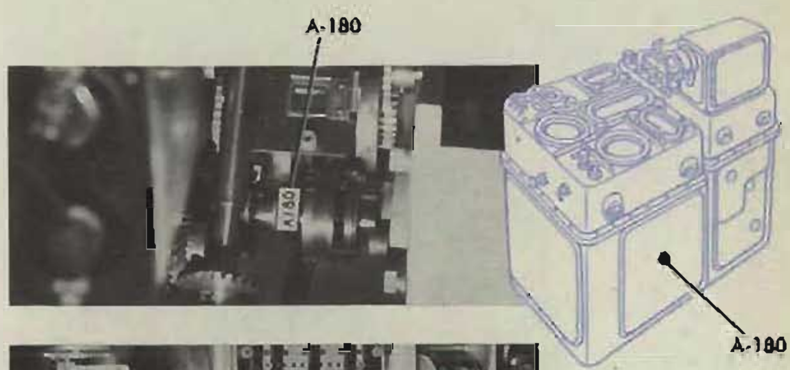
Tighten A-179 and recheck.



A-180 E2 MASTER COUNTER to E DIALS

Location

A-180 is under cover 5, at the lower center, between two couplings.



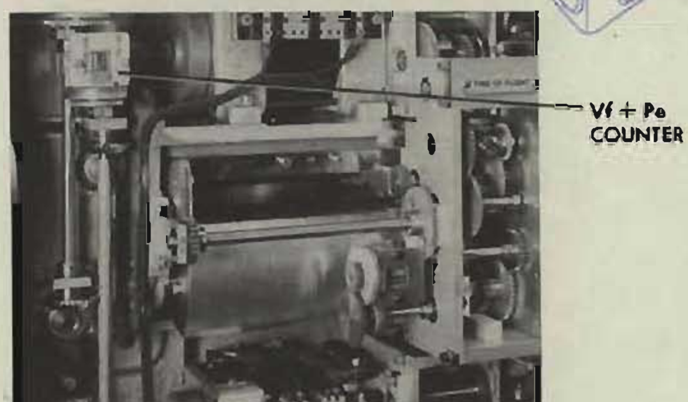
Check

Turn the power OFF.

Set $Vf + Pe$ at 0′ by turning the gearing to the $Vf + Pe$ counter at the upper left under cover 4, and wedge the line.

Set $I.V.$ at 2550 f.s., and Vs at 2000′.

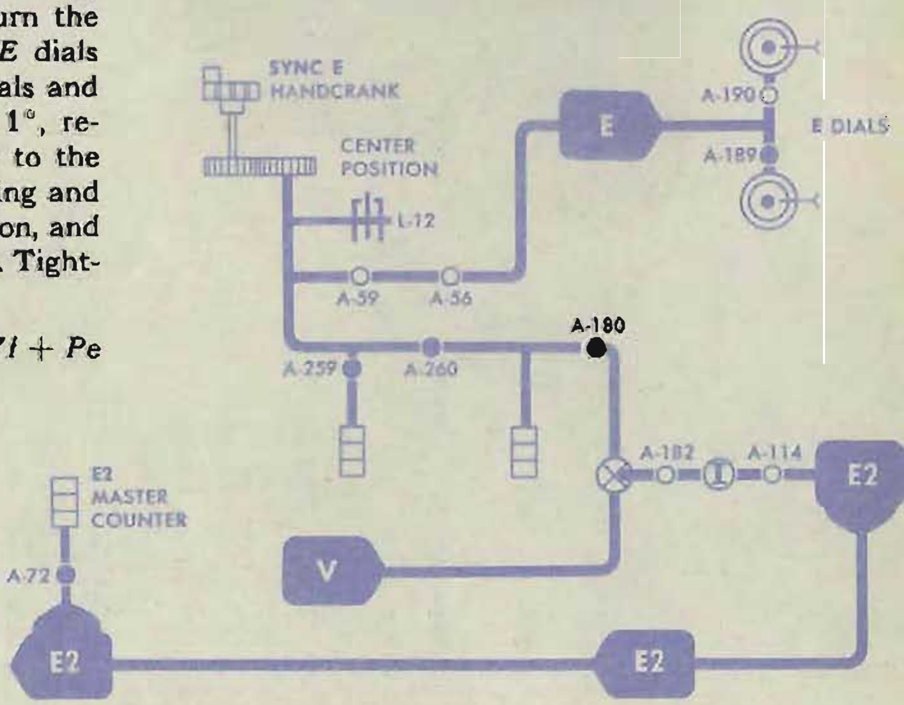
Set the E dials at 1°.
The $E2$ master counter under cover 4 should read 1°, the same as the E dials.



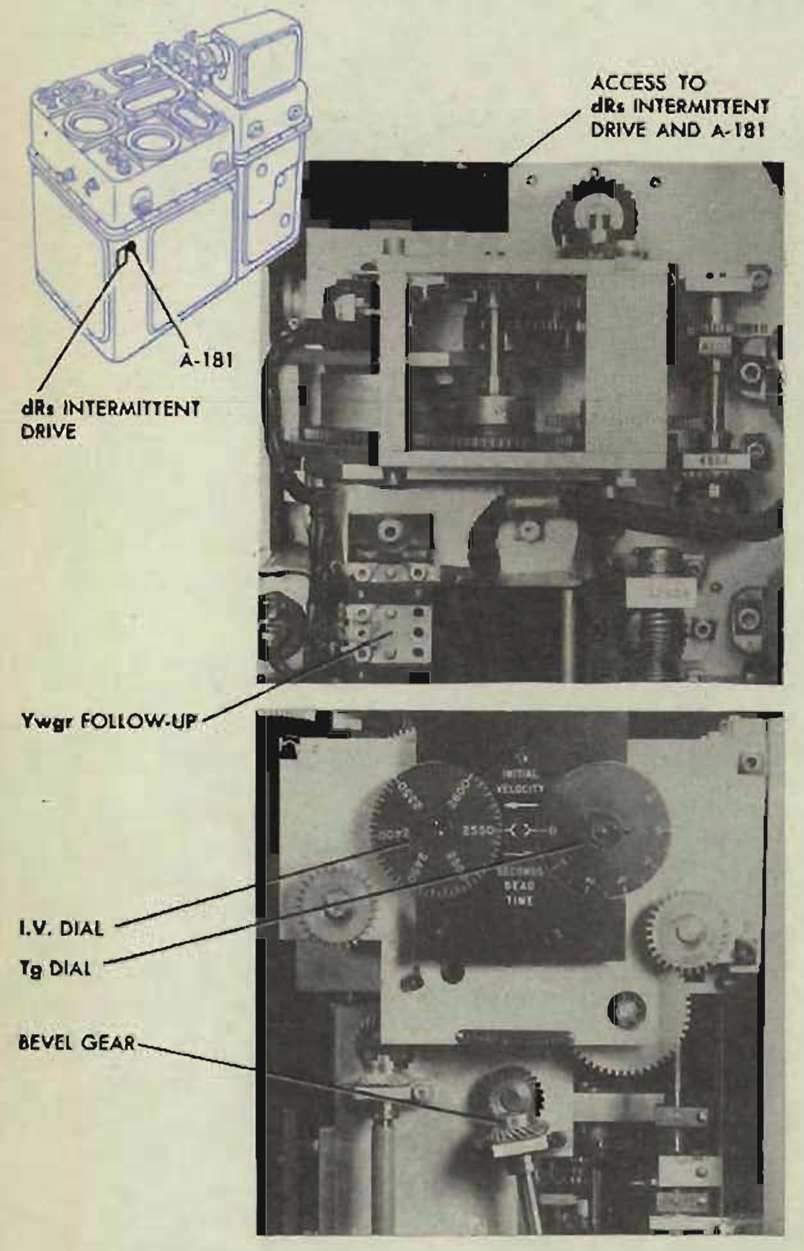
Adjustment

If the $E2$ counter does not read the same as the E dials, make A-180 slip-tight. Turn the sync E handcrank in its CENTER position until $E2$ reads 1°. Wedge the $E2$ line at the gearing to the $E2$ master counter. Turn the sync E handcrank until the E dials read 1°. When both the E dials and the $E2$ master counter read 1°, remove the $E2$ wedge, bring E to the correct value from an increasing and then from a decreasing direction, and read $E2$. Split any lost motion. Tighten A-180, and recheck.

Remove the wedge from the $Vf + Pe$ line.



A-181 dRs INTERMITTENT DRIVE to dRs LINE



Location

A-181 is under cover 5, on the input to the *dRs* intermittent drive.

Check

Turn the power ON.

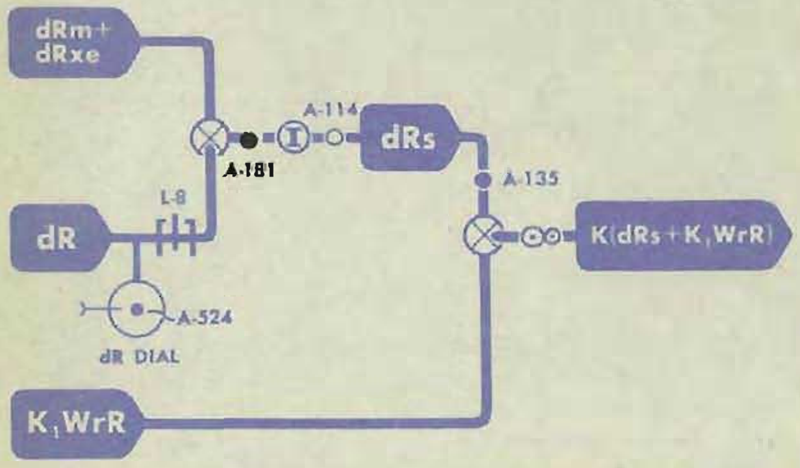
Set *So*, *Sh*, and *dH* at 0 knots.
Set *I.V.* at 2550 f.s.

Decrease *dR*. Use the *dR* handcrank in the HAND position.
Observe the output gear of the *dRs* intermittent drive or the bevel gear at the top of the six-inch shaft below the *Tg* dial. These gears should turn until the *dR* dial reads −450 knots.

The intermittent drive should then be at its low cut-out point. Since the limit stop of the *dR* line also acts at −450 knots, the adjustment of A-181 cannot be accurately checked by changing *dR* alone.

Set *dR* at −450 knots.
Increase *I.V.* from 2350 until the intermittent drive cuts out. Note the reading on the *I.V.* dial.
Decrease *I.V.* from 2600 until the intermittent drive cuts in. Read the *I.V.* dial.

The average of the two readings should be 2550 f.s.
Check that A-114 is tight.



Adjustment

If it is necessary to readjust A-181, slip-tighten A-135 before attempting any adjustment.

If the average of the two *I.V.* readings is not 2550 f.s., make A-181 slip-tight.

CAUTION

Do not loosen A-181 all the way because the clamp gear may slip off the shaft of the intermittent drive.

Use the *I.V.* input to find the cut-out point of the intermittent drive.

Hold the large gear in the intermittent drive, with a gear pusher inserted through the access in the plate above the *Ywgr* follow-up, and turn *I.V.* to 2550 f.s.
Tighten A-181 and recheck.

If the intermittent drive is too far out of adjustment to refine with *I.V.*, decrease *dR* from 0 until the approximate cut-out point is found. Hold the large gear in the intermittent drive and bring *dR* back to —450. Then refine with *I.V.* as described above.

Check the upper cut-out point as follows: Run the *dR* line to the upper limit. The intermittent drive output should continue turning until *dR* reaches +450 knots. Decrease, then increase, *I.V.* through 2550 and read the *I.V.* dial at the cut-out and cut-in points, respectively. The average of the two readings should be 2550 f.s.

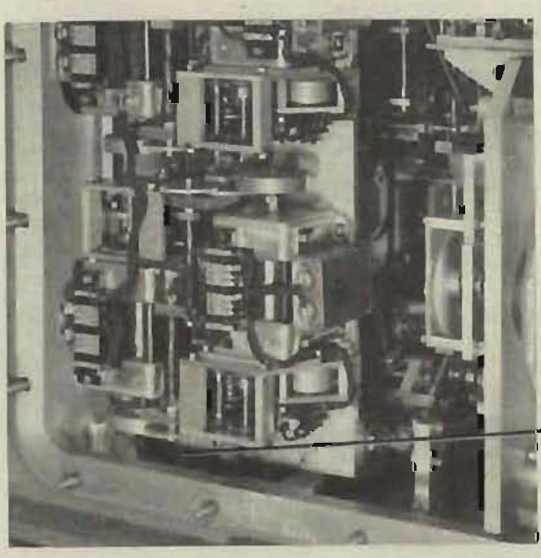
Readjust A-135.

Check A-104. On instruments with Ser. Nos. 781 and higher, also check A-132.

A-182 ASSEMBLY CLAMP

Location

A-182 is under cover 5, on the *E2* intermittent drive input gear, behind the follow-up mounting plate, at the lower front corner. It cannot be reached without removing the mounting plate.



Check

If A-182 has slipped, *E* will no longer match *E2*. Check A-180 for tightness. Bring the *E2* intermittent drive to its cut-in point. If the *E* line can be turned while the *E2* line is held, either A-182 or A-114 is slipping.

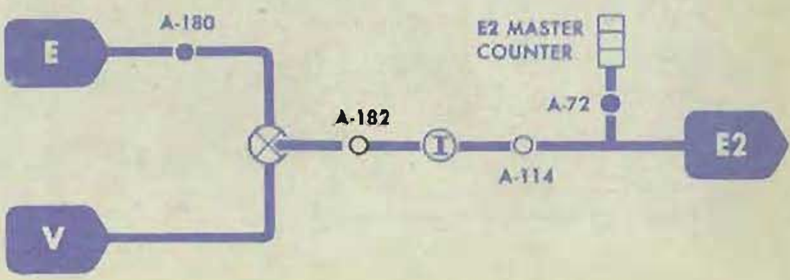
Adjustment

To remove the prediction follow-up mounting plate, refer to page 694.

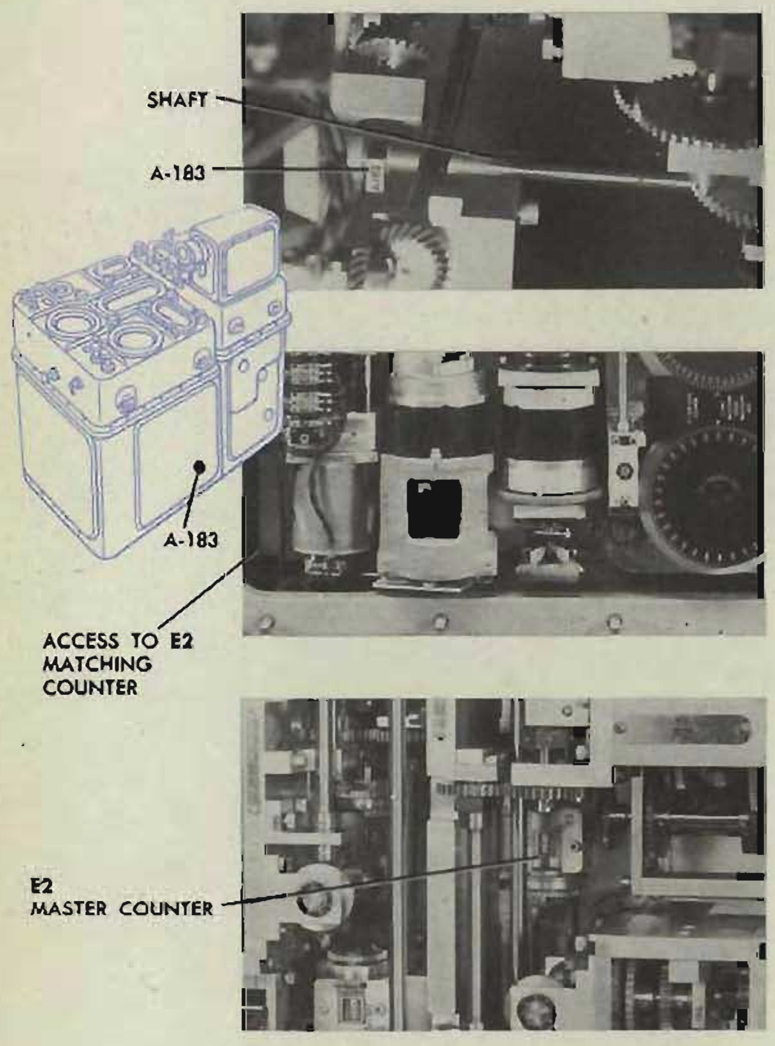
Tighten A-182 and A-114.

Check A-72.

Reinstall the mounting plate. Refer to page 695.



A-183 E2 MATCHING COUNTER to E2 MASTER COUNTER



Location

A-183 is under cover 5, near the lower rear corner of the follow-up mounting plate.

The *E2* matching counter is under cover 6.

The *E2* master counter is under cover 4, in the center of the ballistic section, directly above clamp A-72.

Check

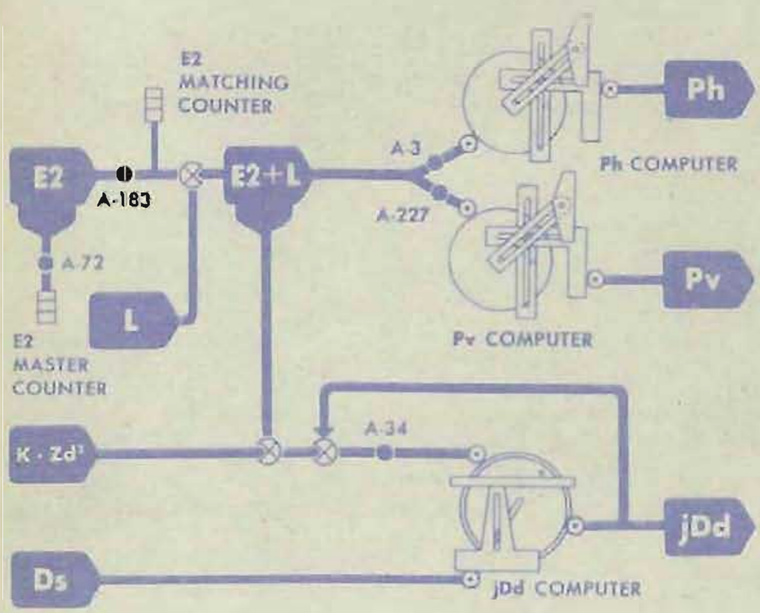
The *E2* counters should agree.

Adjustment

If the *E2* counters do not agree, loosen A-183.

Set an even reading on the *E2* master counter.

Turn the shaft to the rear of A-183 until the *E2* matching counter reads the same as the *E2* master counter. Tighten A-183, and recheck.



IMPORTANT

If the *E2* counters cannot be brought to the same value, A-34, A-3, or A-227 may be in error. Loosen and readjust the clamp causing the restriction.

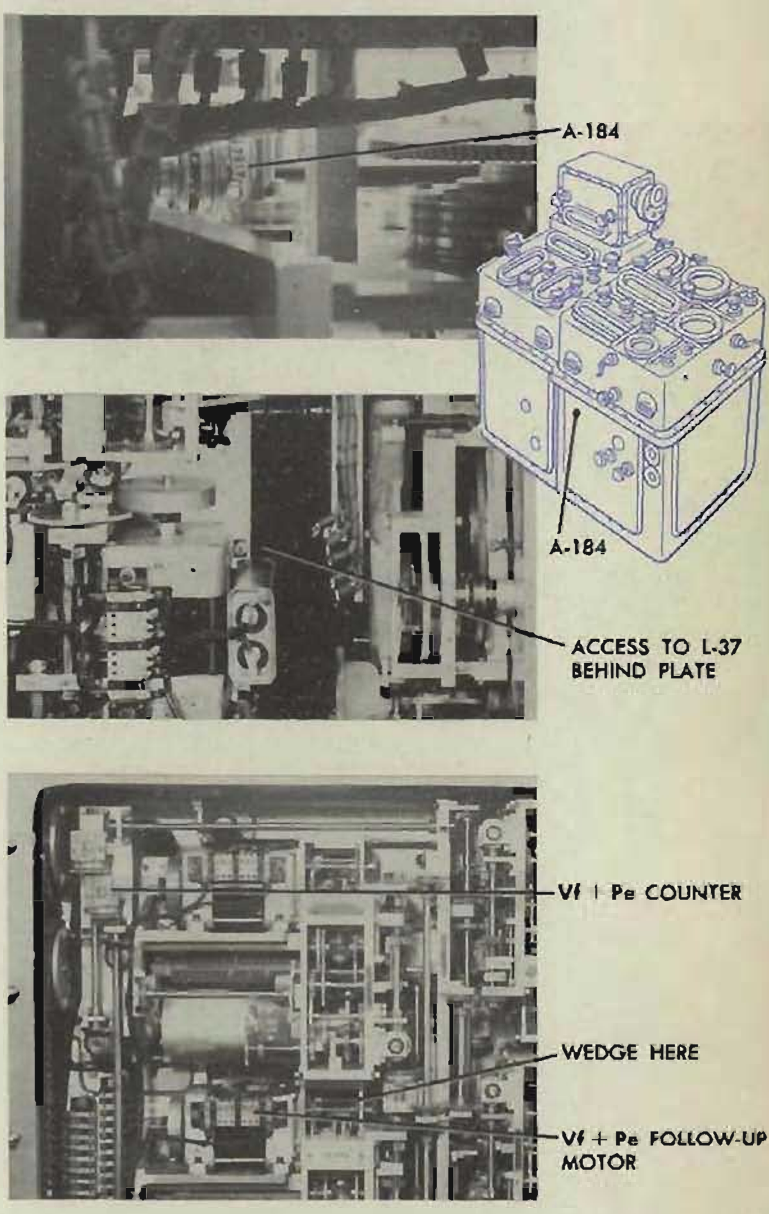
Check A-34, A-3, and A-227.

A-184 Vs COUNTER to L-37

Location

A-184 is under cover 3, about 10 inches in. The clamp is on the rear end of a red shaft, 5 inches below the top plate.

The lower end of L-37 can be seen under cover 5 through the access at the front of the integrator group.



Check

Turn the power OFF.

Set the *Vf* + *Pe* counters at 0′ by turning the follow-up output gearing. Wedge the line.

Set *I.V.* at 2550 f.s.

Decrease *Vs* until L-37 reaches its lower limit. The *Vs* counter should read 200′.

Adjustment

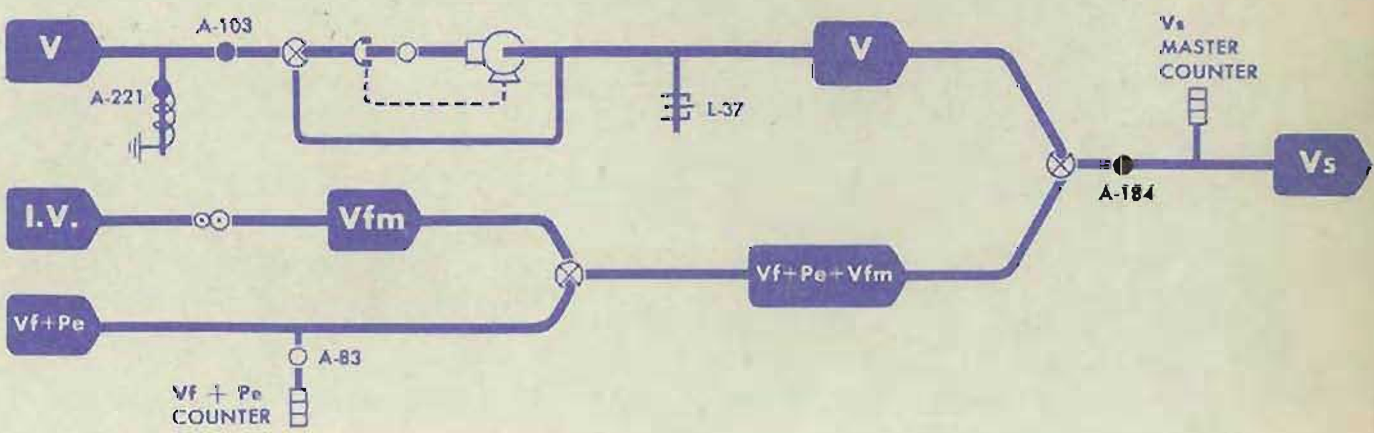
If the *Vs* counter does not read 200′ at the lower limit, make A-184 slip-tight.

Wedge the *V* follow-up output gearing at the lower limit of L-37. Turn *Vs* to 200′.

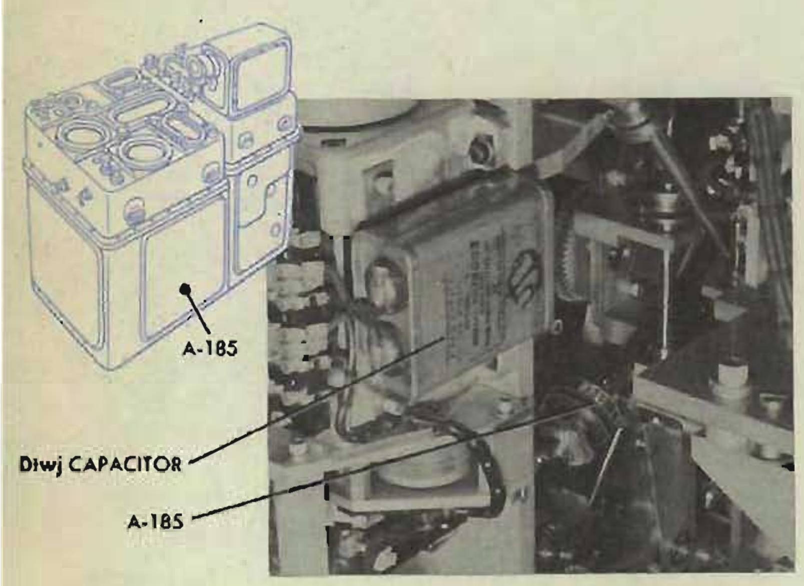
Tighten A-184. Recheck at the upper limit of L-37.

The *Vs* counter should read 3800′.

Check A-103.



A-185 Dj HOLDING FRICTION



Location

A-185 is under cover 5.

Check

The friction should be tight enough to hold the *Dj* setting but not so tight as to overload the *Dj* receiver motor.

Turn the power ON.

Set *Sh* at 400 knots.
Set *A* at 90°.
Turn the *cR* line rapidly.
No motion of *Dtw'* should back through the *Dj* line.

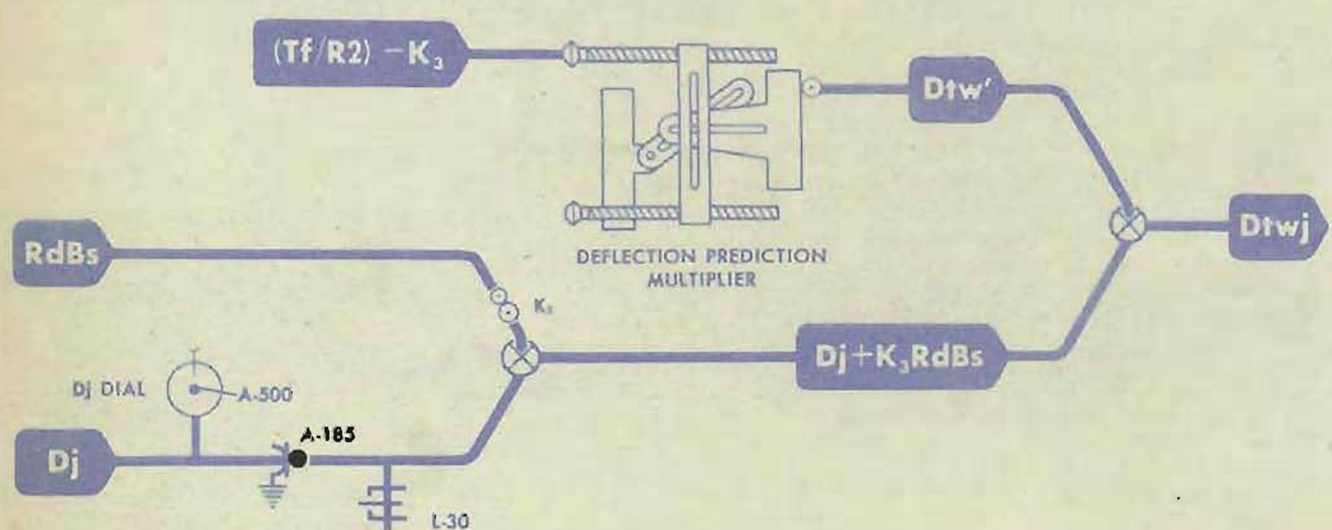
Run the synchronizing test of the *Dj* receiver, page 62. Check that the synchronizing time is within the allowable limits.

Adjustment

If *Dtw'* is backing through the *Dj* line, loosen A-185. Then turn the clamp clockwise to increase the friction.

If the *Dj* receiver motor runs too slowly, loosen A-185 and turn the clamp counterclockwise to decrease the friction.

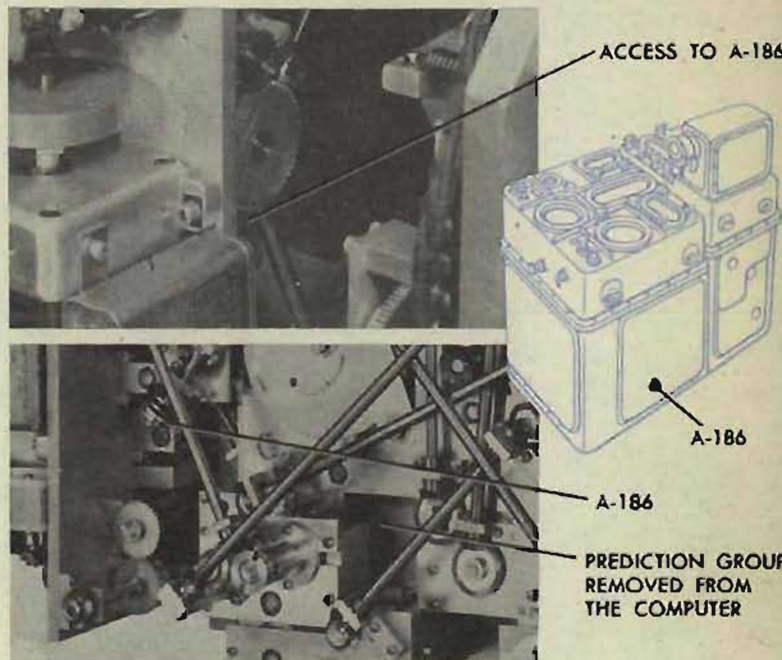
Tighten A-185 and recheck.



A-186 Vj HOLDING FRICTION

Location

A-186 is under cover 5, on a diagonal shaft, 2 inches in back of the follow-up mounting plate.



Check

The *Vj* holding friction should be tight enough to hold the *Vj* setting but not so tight as to overload the *Vj* receiver motor.

Turn the power ON.

Set *E* at 0°.
Set *dH* at DIVE 250.
Turn the *cR* line rapidly.
No motion of *Vtw'* should back through the *Vj* line.

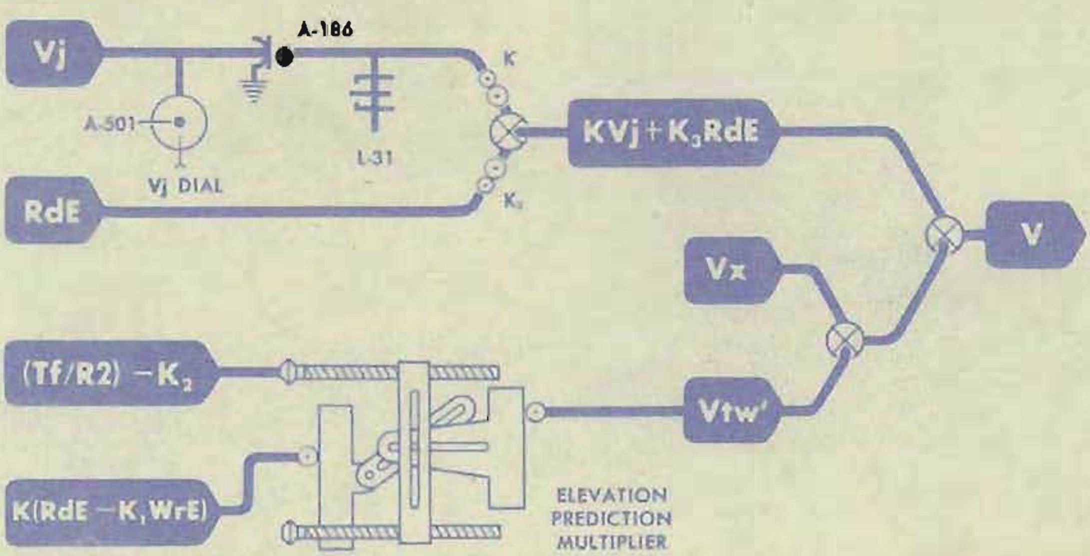
Run the synchronizing test of the *Vj* receiver, page 62.
Check that the synchronizing time is within the allowable limits.

Adjustment

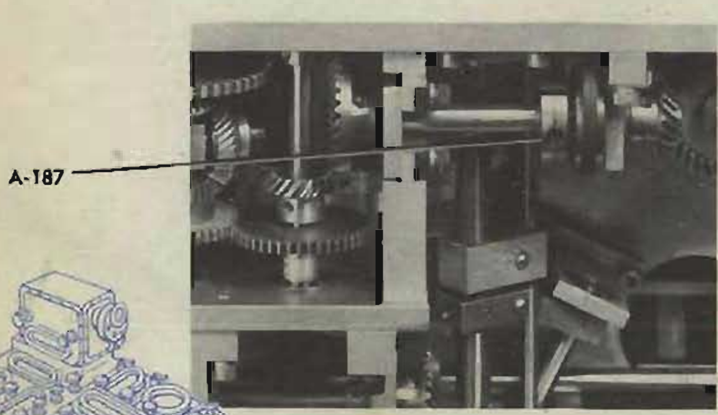
If *Vtw'* is backing through the *Vj* line, loosen A-186.
Turn the clamp clockwise to increase the friction.

If the *Vj* receiver motor runs too slowly, loosen A-186 and turn the clamp counterclockwise to decrease the friction.

Tighten A-186 and recheck.

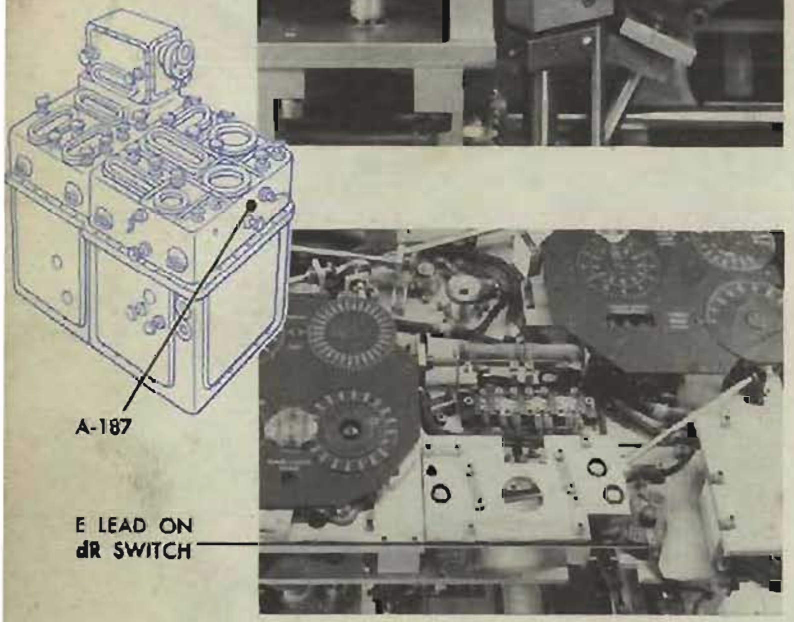


A-187 jR HOLDING FRICTION



Location

A-187 is under cover 1, at the front.

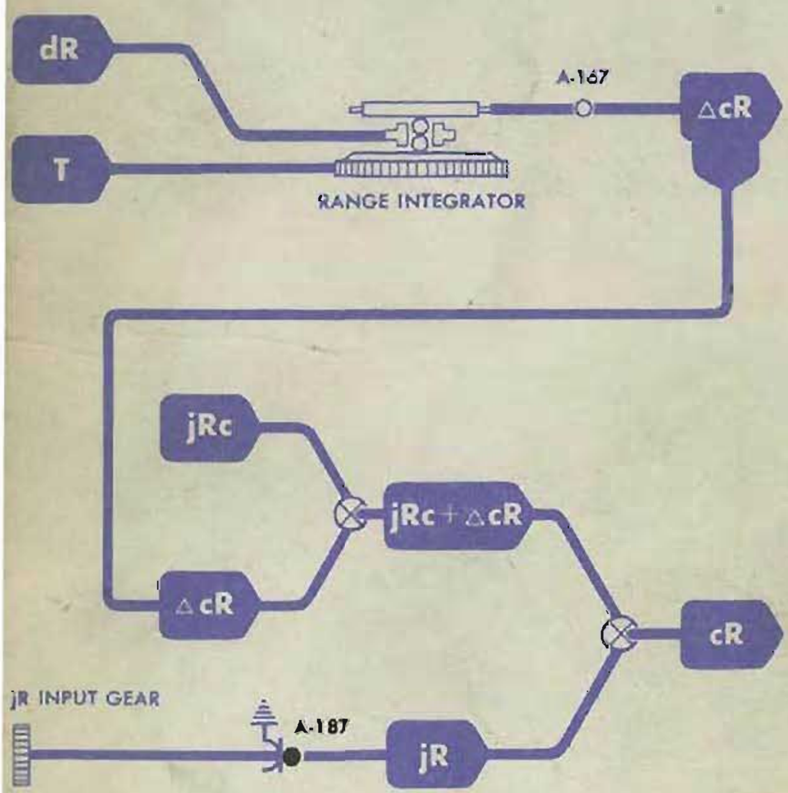


Check

This friction should hold the *jR* setting without too much drag on the line.

Remove the E lead from the *dR* switch.
Turn the power ON.
Turn the time motor ON.

Set *dR* at —450 knots to offset the carriage of the range integrator so that the output roller will turn. The integrator output should not back through A-187 to the *jR* input.



Adjustment

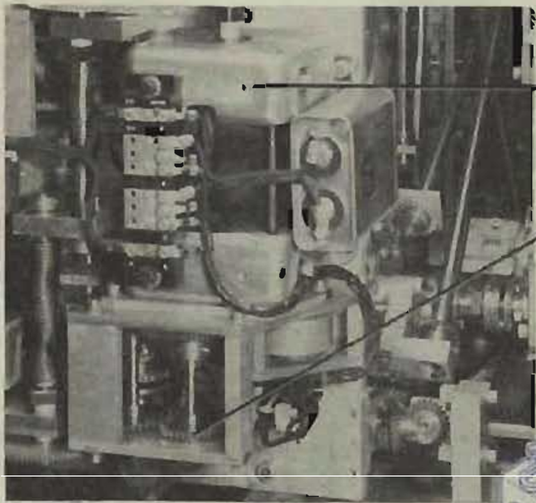
If the range integrator output backs out the *jR* input, loosen A-187. Turn the clamp clockwise to increase the friction.

Tighten A-187, and recheck.

A-188 DEAD TIME MULTIPLIER to Tg DIAL

Location

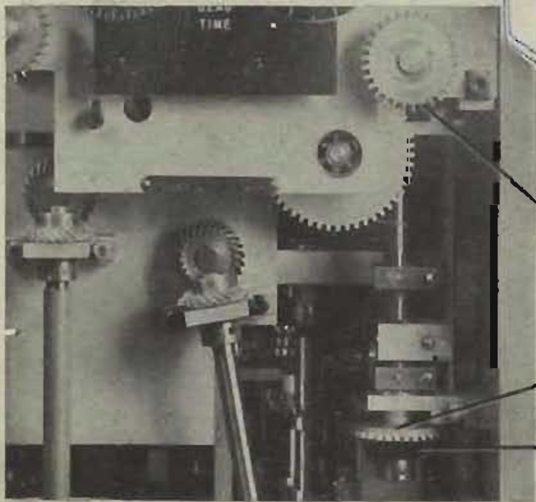
A-188 is under cover 3, on the bevel gear at the lower end of L-14.



Check

Turn the power OFF.

Set *Tg* at 0 seconds. Use the *Tg* input gear.
On instruments with Ser. Nos. 781 and higher, set *F* and *Tf* at 10 seconds.
Wedge the *R2* follow-up output gearing.

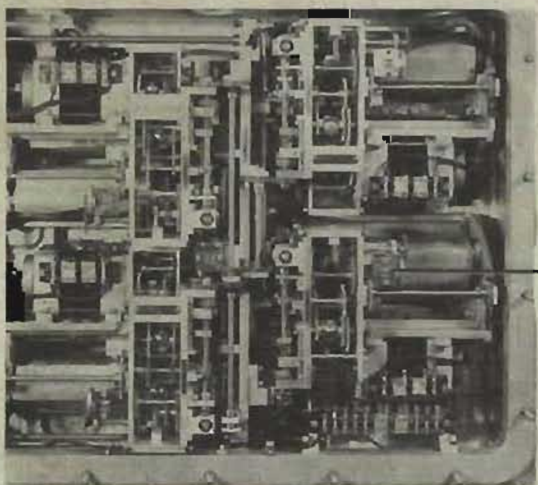


Set *dR* at —450 knots. Note the value on the *R3* counter under cover 4. Turn *dR* to +450 knots.

The *R3* counter reading should not change.

Adjustment

If the *R3* counter reading changes, make A-188 slip-tight. Hold *Tg* at 0 and turn the bevel gear next to the clamp, to correct halfway back to the original *R3* reading.



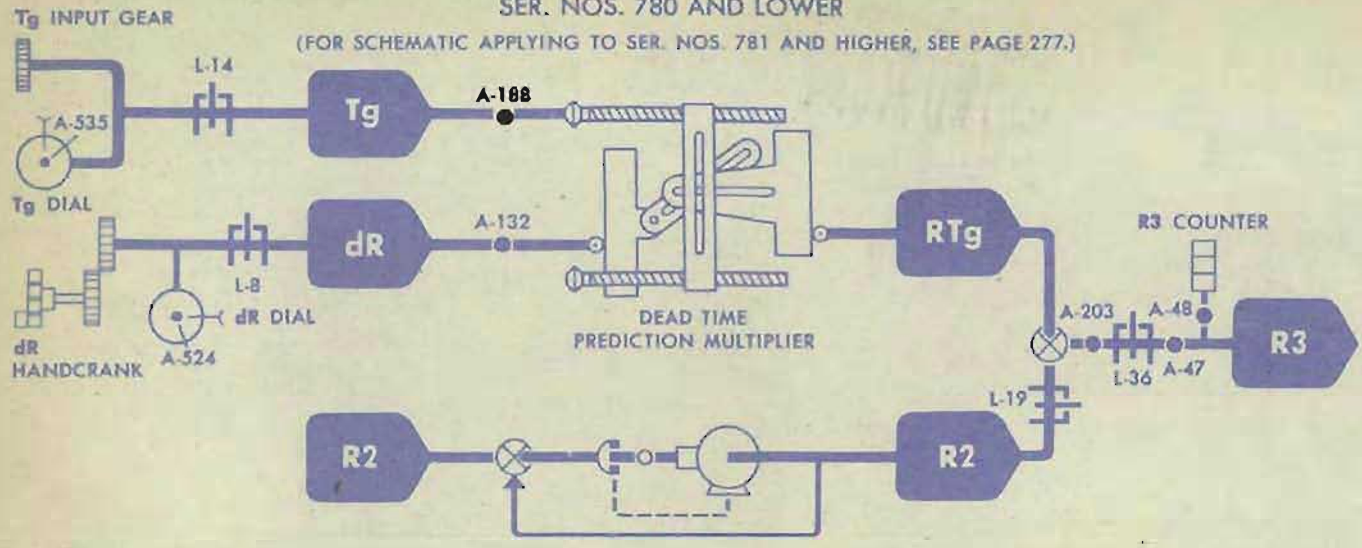
Tighten A-188 and recheck.

Remove the wedge from the *R2* follow-up.

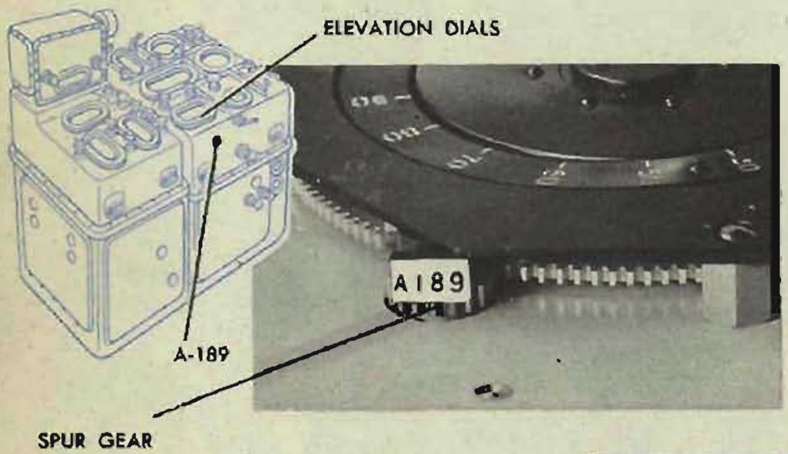
Check A-203.

SER. NOS. 780 AND LOWER

(FOR SCHEMATIC APPLYING TO SER. NOS. 781 AND HIGHER, SEE PAGE 277.)



A-189 COARSE to FINE E DIALS



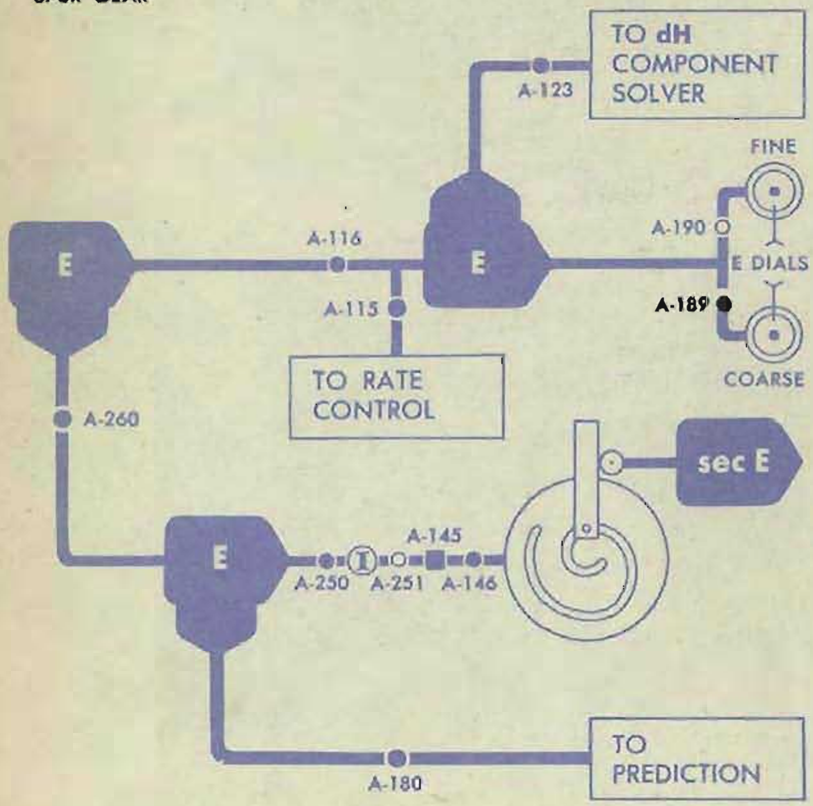
Location

A-189 is under cover 1, beneath the mask of the elevation dials, to the left of the coarse *E* dial.

Check

Set the fine *E* dial at 0°. One of the graduations of the coarse *E* dial should line up with the fixed index.

Before readjusting A-189, check A-190.



Adjustment

If the coarse dial does not read correctly, make A-189 slip-tight.

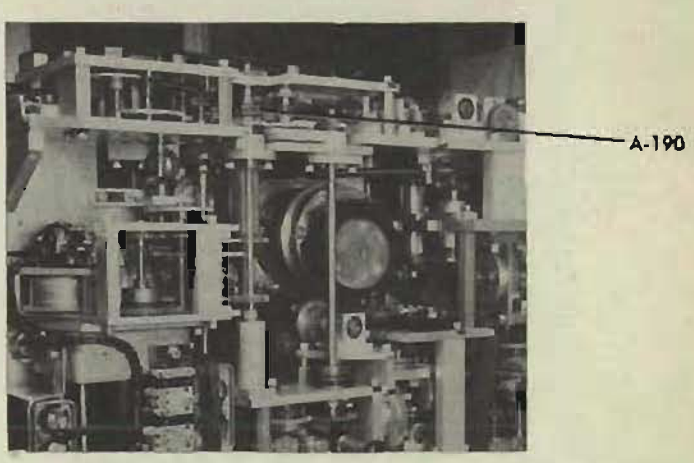
Set the fine dial at 0°. Bring the nearest graduation of the coarse dial to the fixed index by turning the spur gear directly below A-189. Tighten the clamp and recheck.

Check A-116, A-115, A-123, A-180, A-260, A-250, and A-145.

A-190 ASSEMBLY CLAMP

Location

A-190 is under cover 1, near the fine *E* dial.



Check

If A-190 is loose or has slipped, the fine and coarse *E* dials will no longer match.

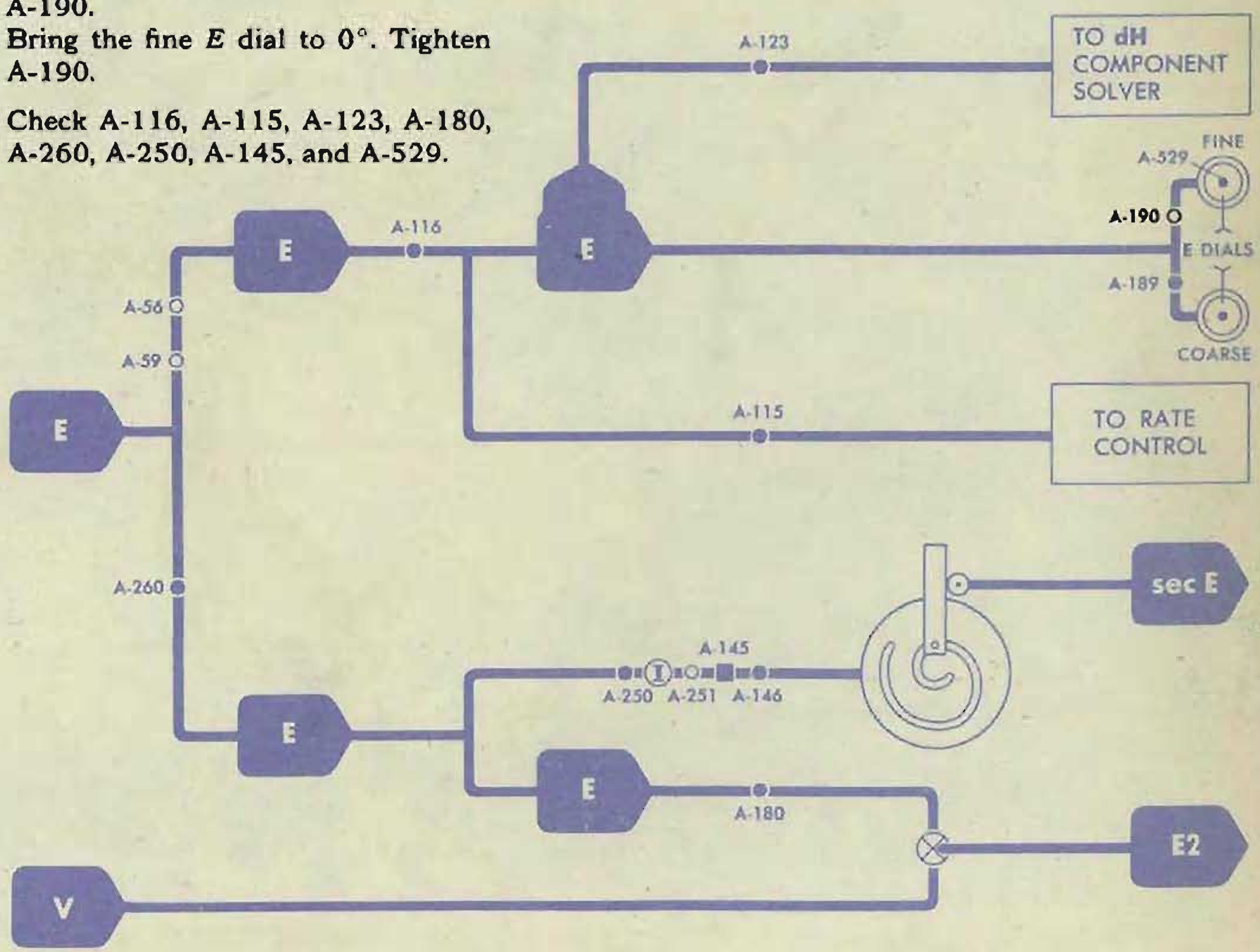
At the upper limit, the fine *E* dial will not read 5°0′, although the coarse dial reading will be halfway between the 80° and 90° graduations.

If both these conditions exist, A-190 should be readjusted.

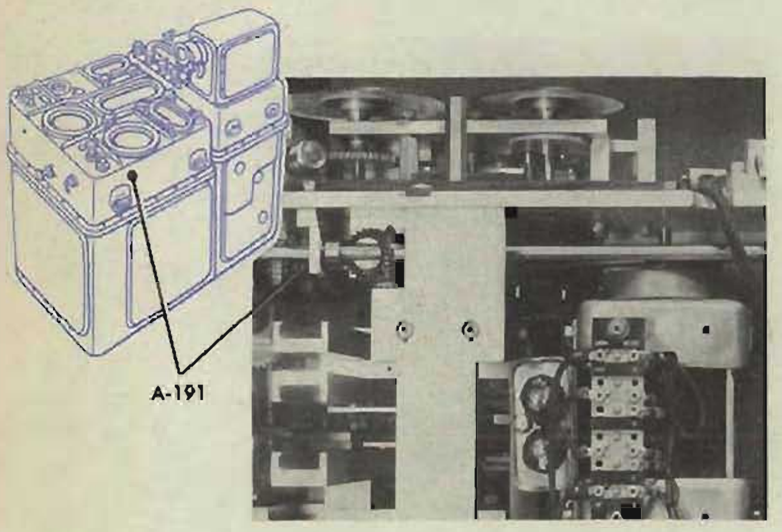
Adjustment

Set the coarse *E* dial at 0°. Loosen A-190.
Bring the fine *E* dial to 0°. Tighten A-190.

Check A-116, A-115, A-123, A-180, A-260, A-250, A-145, and A-529.



A-191 FRICTION DRIVE to TIME DIAL

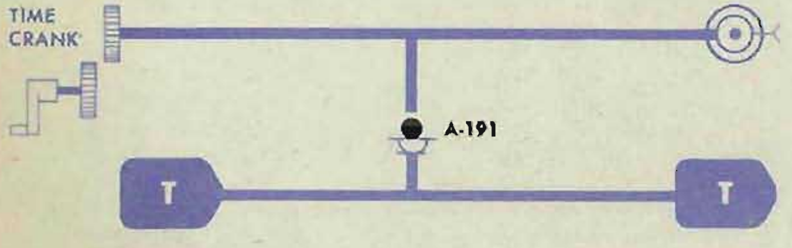


Location

A-191 is under cover 1, at the right side.

Check

This friction should slip when the time crank is pushed IN and turned. It should drive when the time crank is pulled OUT and turned, or when the time line is driven by the time motor.

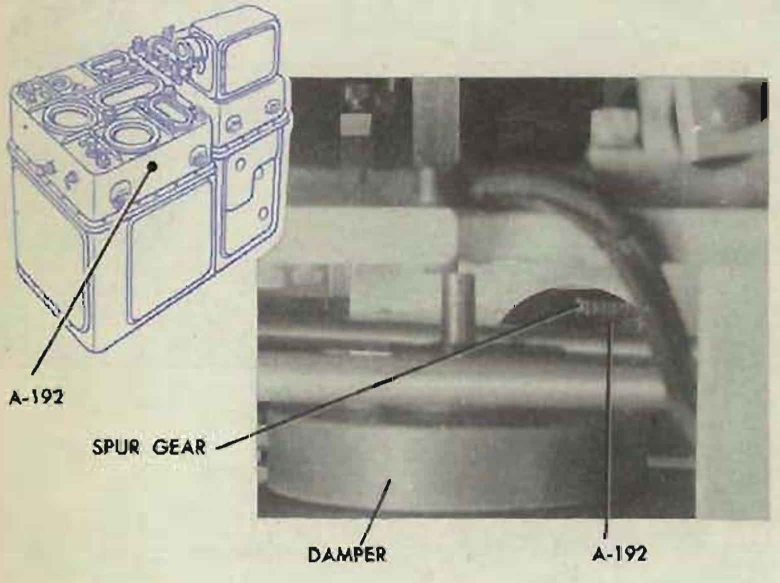


Adjustment

If the friction is not adjusted properly, loosen A-191. Turn the clamp clockwise to increase the friction, or counterclockwise to decrease it.

Tighten the screw, and recheck.

A-192 TARGET COMPONENT SOLVER to Sh COUNTER



Location

A-192 is under cover 1, behind the damper on the *RdBs* follow-up.

Possible damage

If A-192 is upset, the pin and cam groove in the target component solver may be damaged. Check for damage by running the *Sh* line through its full travel and noting any restriction.

Check

Remove the KRR lead on the target angle switch.
Turn the power ON.

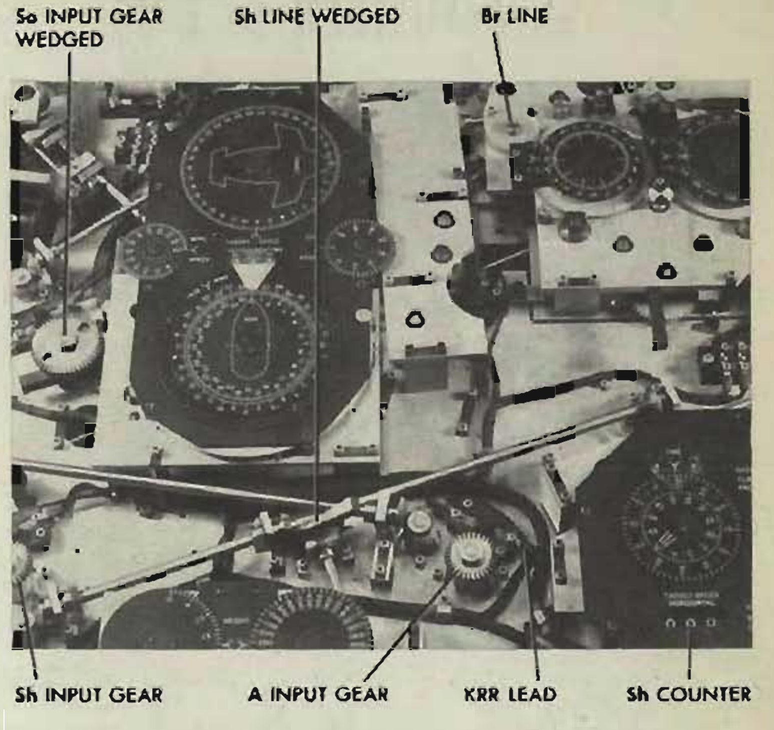
Set *Br* at 0°. Wedge the line.
Set *So* and *Sh* at 0 knots. Wedge the input gears.

Set *A* at 90°.

The ship component solver outputs are now at zero.
The *RdBs* follow-up will indicate motion only from the target component solver.

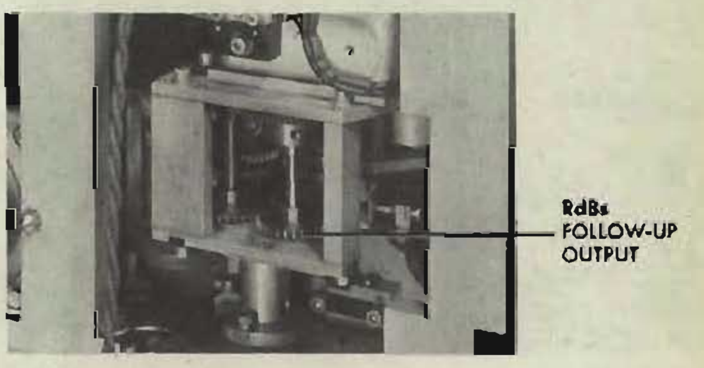
Mark the *RdBs* follow-up output gearing for use as an indicator.

Turn *A* from 90° to 270°.
The follow-up indicator marks should remain matched.



Adjustment

If the indicator marks do not stay matched, slip-tighten A-192. Use a gear pusher to turn the spur gear, on which A-192 is located, until the indicating mark on the *RdBs* follow-up gear is halfway back to its original position. Tighten A-192.



Recheck

Set *A* at 90°.
Remove the old indicator marks and make new ones.
Turn *A* to 270°.

Check the movement of the marks. The error, if any, should be less than half a tooth movement.

Remove all wedges.
Replace the KRR lead.
Check A-121 and A-119.

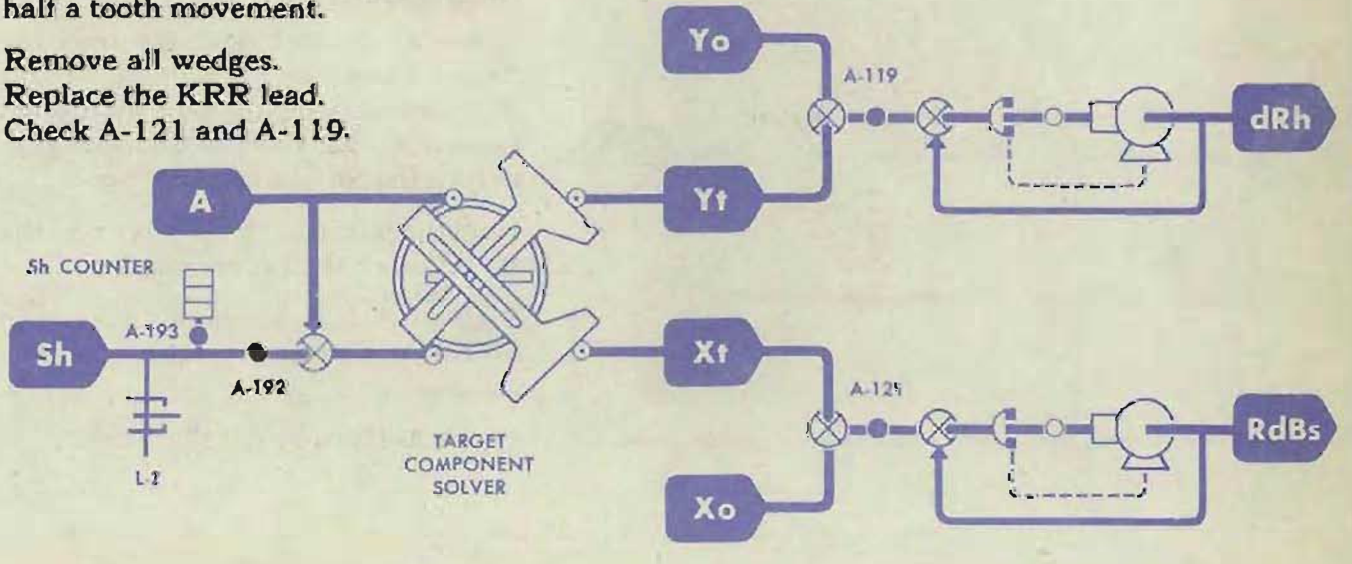
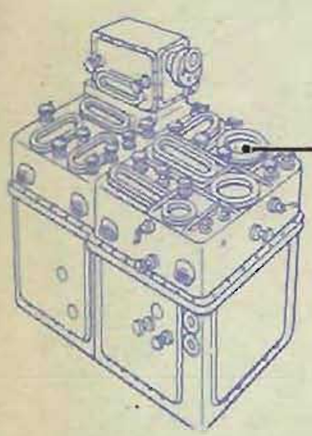
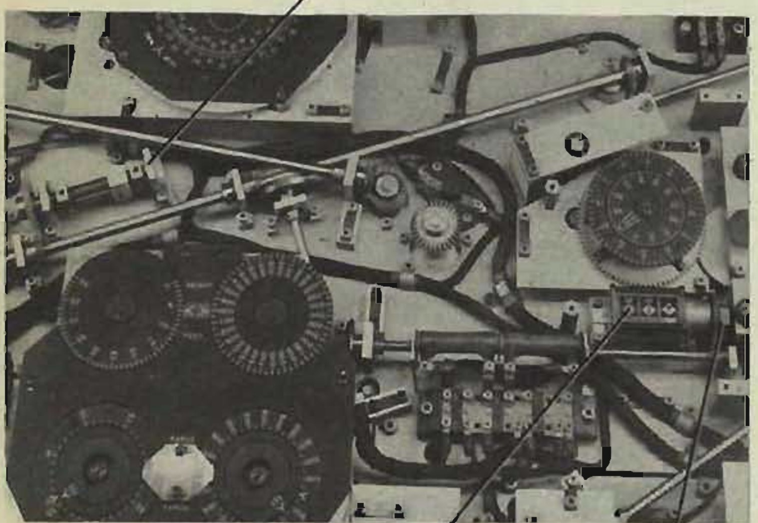
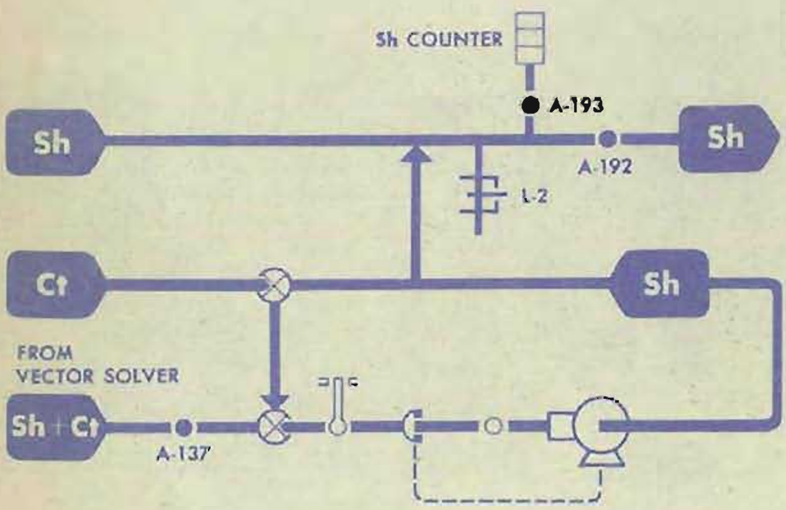


Table of Contents

A-193 Sh COUNTER to L-2







Location

A-193 is under cover 1, on the *Sh* counter shaft under the mask.

L-2 is under cover 1, to the rear of the coarse *H* dial. The lower limit is toward the right.

Check

Turn the power OFF.

Turn the *Sh* line to either limit.
At the upper limit, the *Sh* counter should read 400 knots; at the lower limit, 0 knots.

If either limit cannot be reached, A-192 or A-137 may be causing the restriction.
Determine which is in error and loosen it.

Adjustment

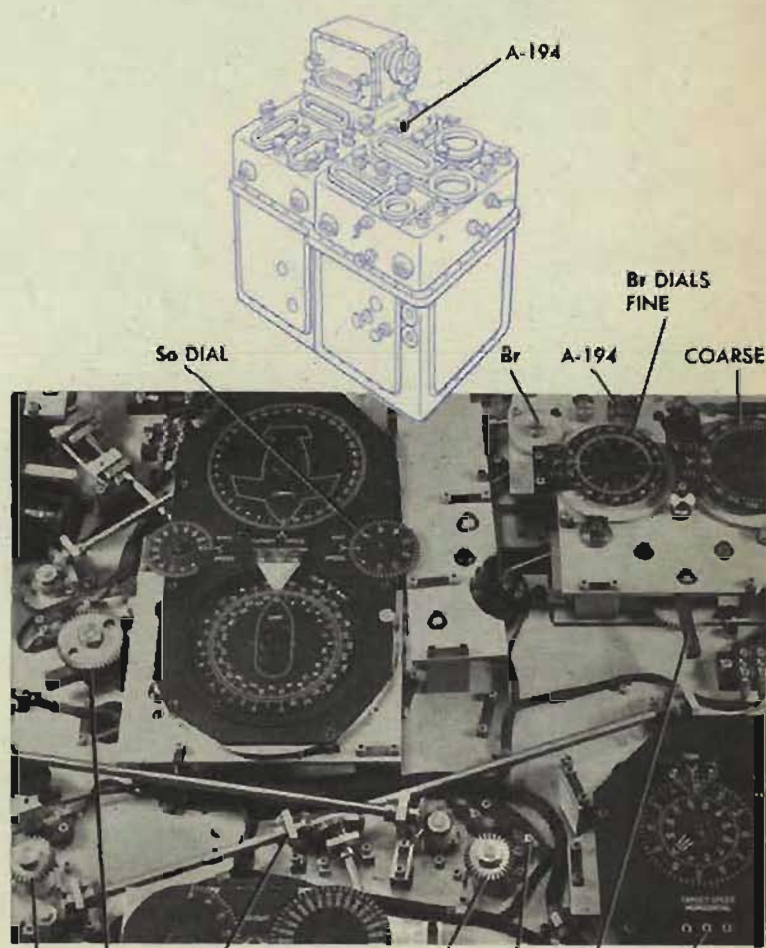
If the *Sh* counter does not read the proper values for each limit, remove the mask covering the time dial group. Loosen A-193. Use the *Sh* input gear to turn the *Sh* line to either limit.

Hold the line against the stop. Slip the *Sh* counter to its proper reading.

Tighten A-193. Recheck by turning *Sh* between its limits and reading the counter.

Check A-192 and A-137.

A-194 SHIP COMPONENT SOLVER to Br RING DIALS



Location

A-194 is under cover 1, below the bearing dial mask, to the rear of the fine *Br* dial.

Check

Disconnect lead KRR from the target angle push-button switch to prevent the *A* and *Sh* follow-ups from driving.

Turn the power ON.

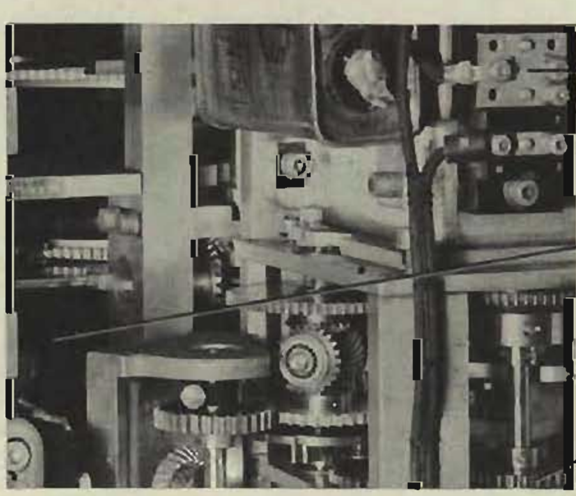
Set *Br* at 180°. Wedge the line at the dial unit.

Set *A* at 0°, and *Sh* at 0 knots. Wedge the lines.

Set *So* at 0 knots.

The ship component solver vector-gear slot should be forward. Check its position by looking through the access at the right front, just forward of the *RdBs* follow-up. The ship component solver is the bottom component solver.

Movement of the *RdBs* follow-up output gearing will indicate motion of the *Xo* rack of the ship component solver. Mark the *RdBs* follow-up output gear for use as an indicator.



Run *So* from 0 to 45 knots. There should be no motion of the *Xo* rack.

Observe the follow-up indicator marks. They should remain matched for full travel of *So*.

Adjustment

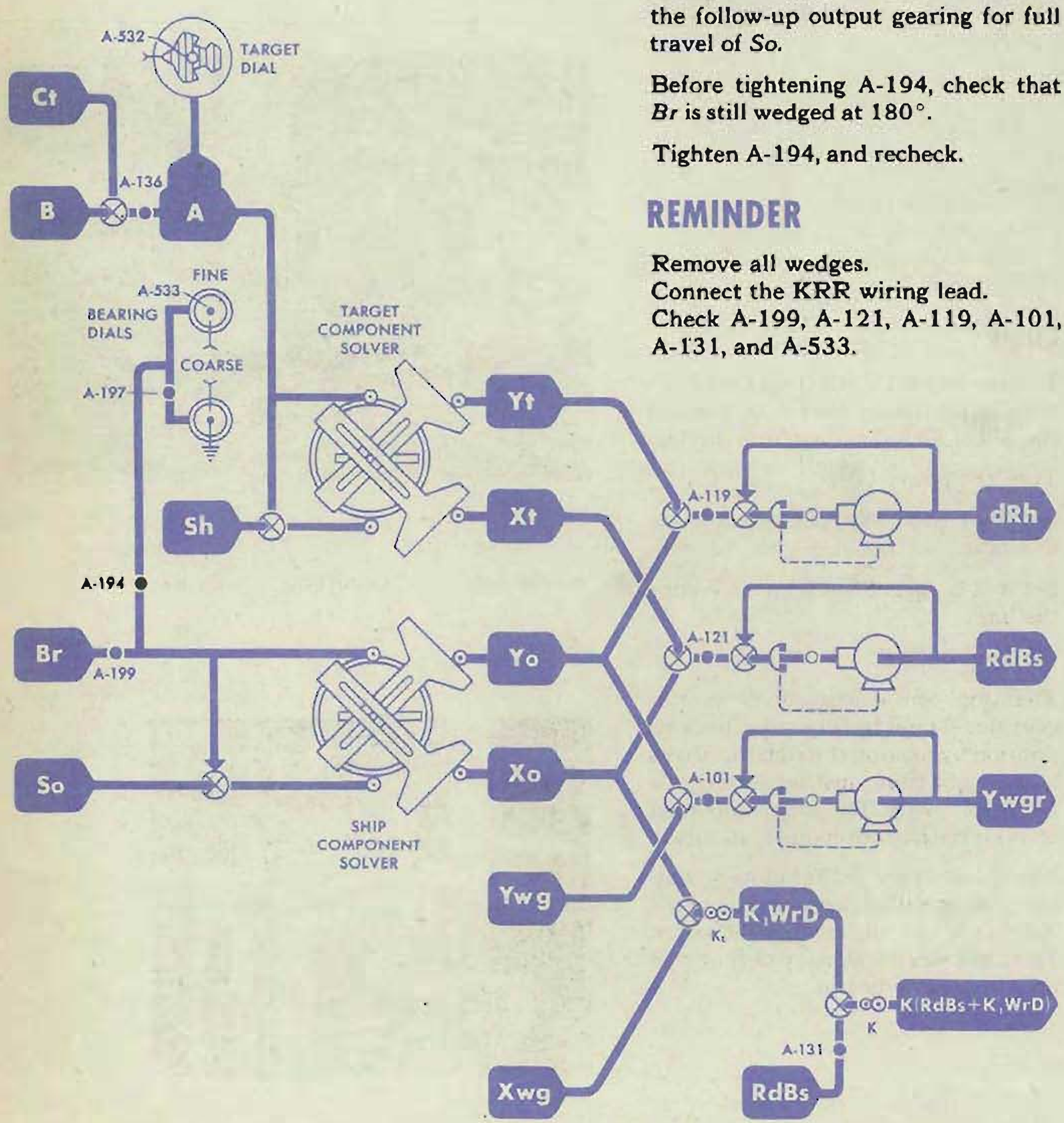
If the marks do not remain matched, slip-tighten A-194. With a gear pusher, turn the ship component solver vector gear until its slot is at a position where there is no movement of the follow-up output gearing for full travel of *So*.

Before tightening A-194, check that *Br* is still wedged at 180°.

Tighten A-194, and recheck.

REMINDER

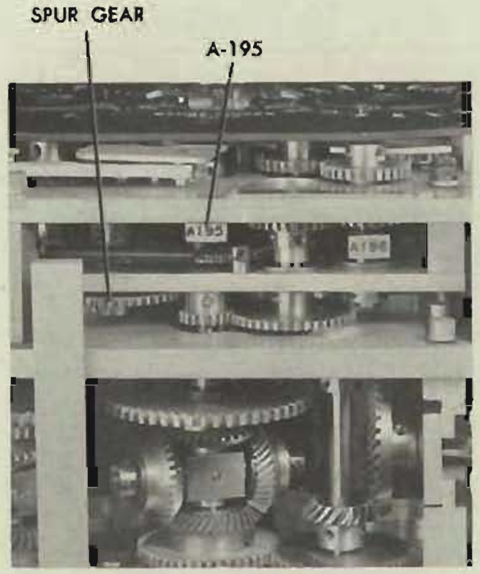
Remove all wedges.
Connect the KRR wiring lead.
Check A-199, A-121, A-119, A-101, A-131, and A-533.

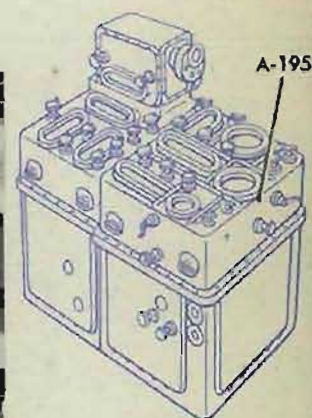


A-195 COARSE to FINE cR DIAL

Location

A-195 is under cover 1, below the *cR* dial mounting plate.





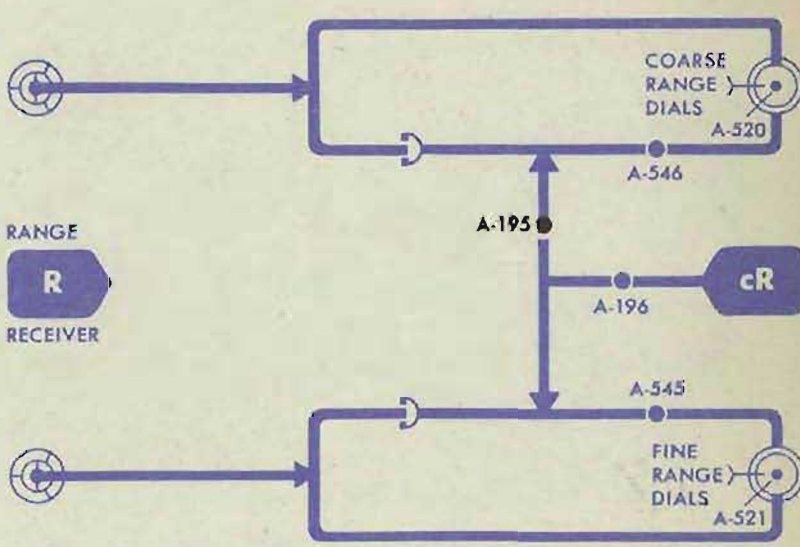
Check

Turn *cR* until the index on the fine ring dial matches the fixed index. An even thousand graduation of the coarse ring dial should also be at the fixed index.

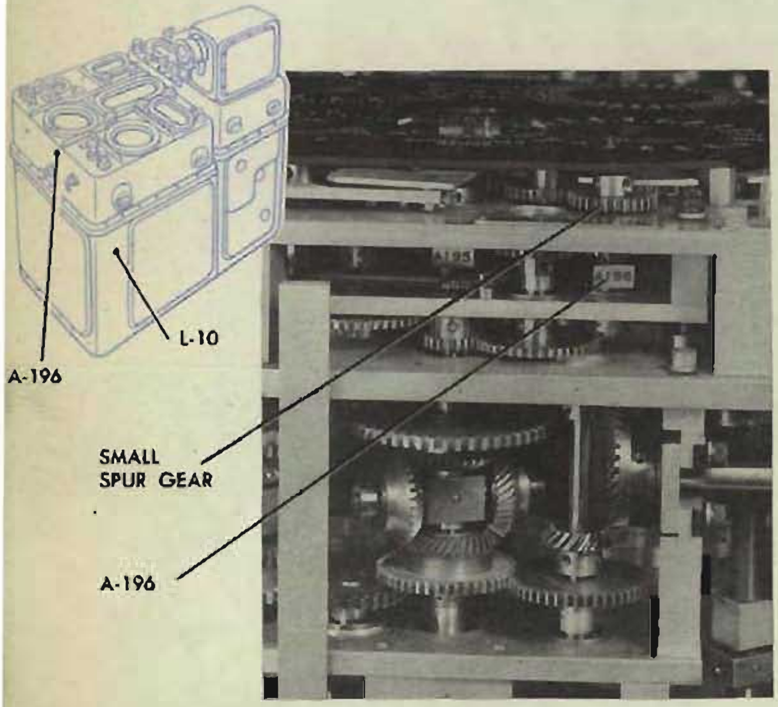
Adjustment

If an even thousand graduation is not at the fixed index, slip-tighten A-195. Bring an even thousand graduation of the coarse dial to the fixed index by turning the spur gear below the left front of the *cR* dial mask.

Tighten A-195, and recheck.
Check A-196.



A-196 cR DIALS to L-10



Location

A-196 is under cover 1, below the *cR* dial mounting plate.

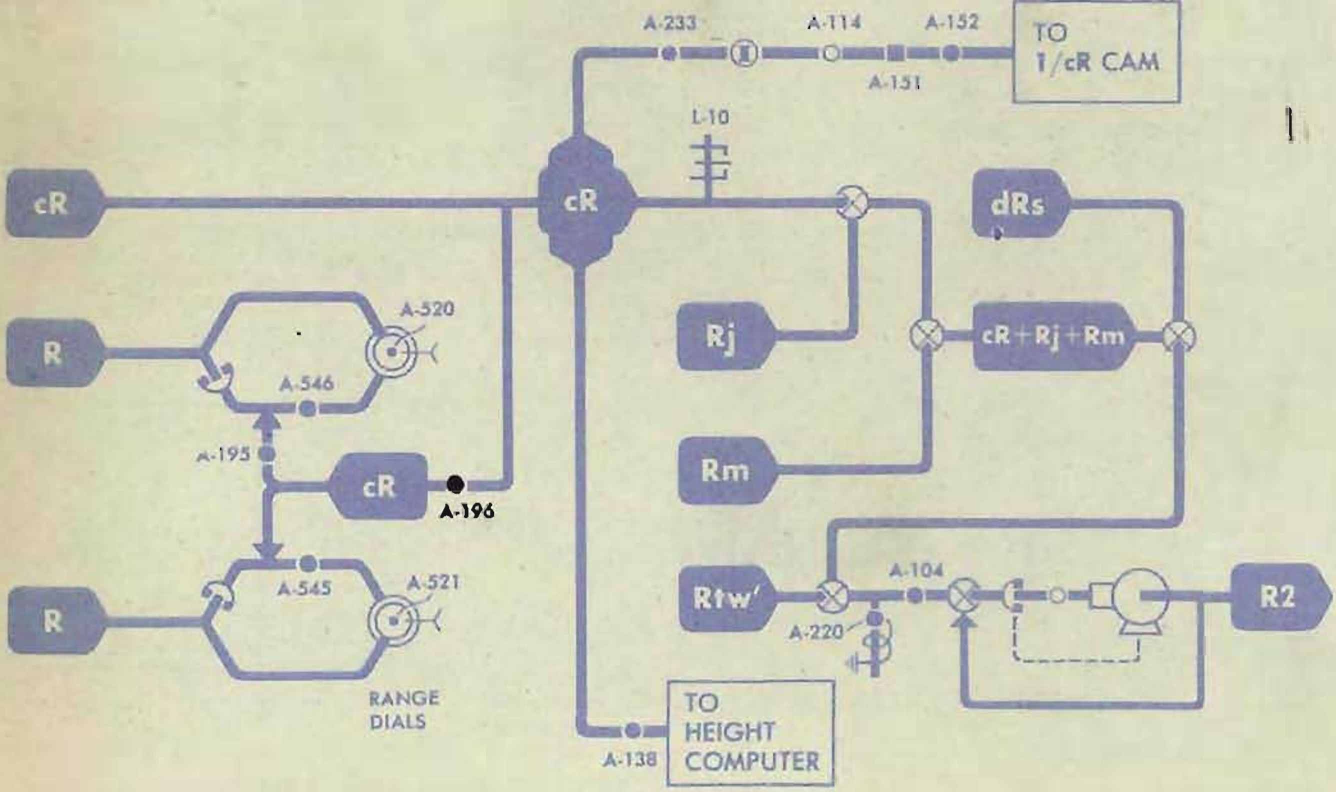
L-10 is under cover 5. It is in a horizontal position with its lower limit toward the rear.

Check

L-10 should operate at 0 and 35,000 yards on the *cR* dials, except in Mods 0, 1, 2, and 9. In these mods the limits are 0 and 22,500 yards.

IMPORTANT: If either limit cannot be reached, A-138 or A-233 may be causing an obstruction. Determine which clamp is upset, and loosen it.

Turn *cR* until the lower limit of the stop is reached. The *cR* dials should read 0 yards.



Adjustment

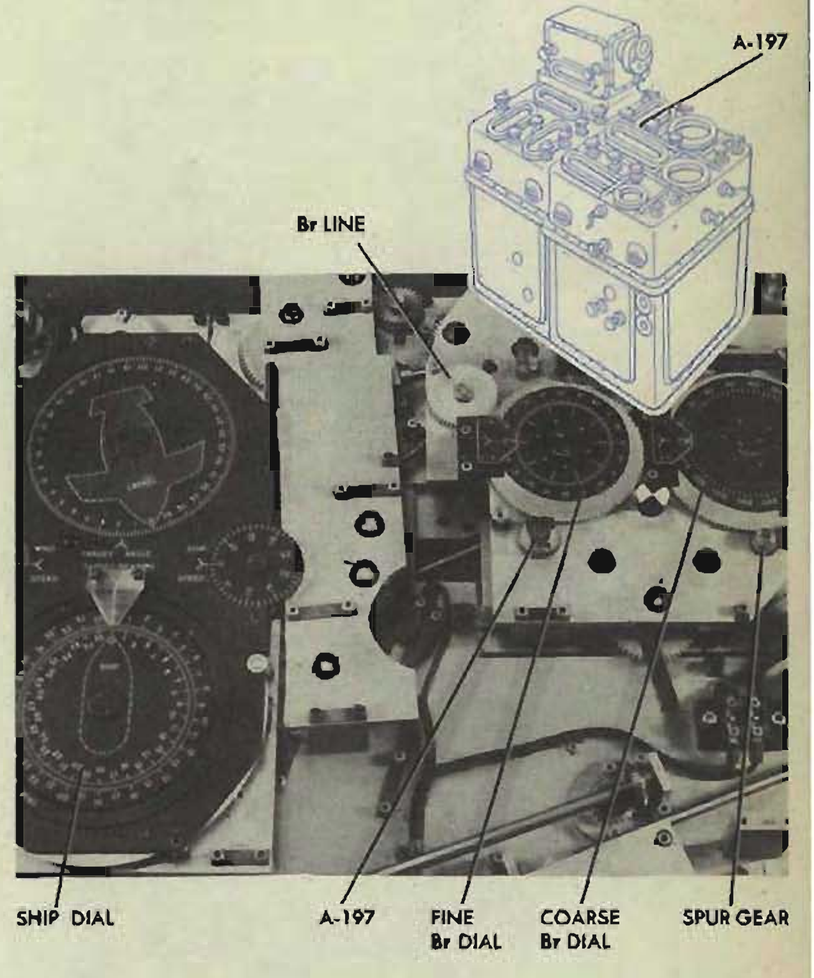
If the *cR* dials do not read 0 yards, hold the line against the stop. Loosen A-196.
Bring the *cR* dials to zero by using a gear pusher to turn the small spur gear under the right front of the dial mask.

Tighten A-196.
Recheck by running *cR* to the upper limit.
Check A-138, A-233, A-151, and A-104.

A-197 COARSE to FINE Br RING DIAL

Location

A-197 is under cover 1, below the front of the bearing dial mask, near the fine *Br* dial.



Check

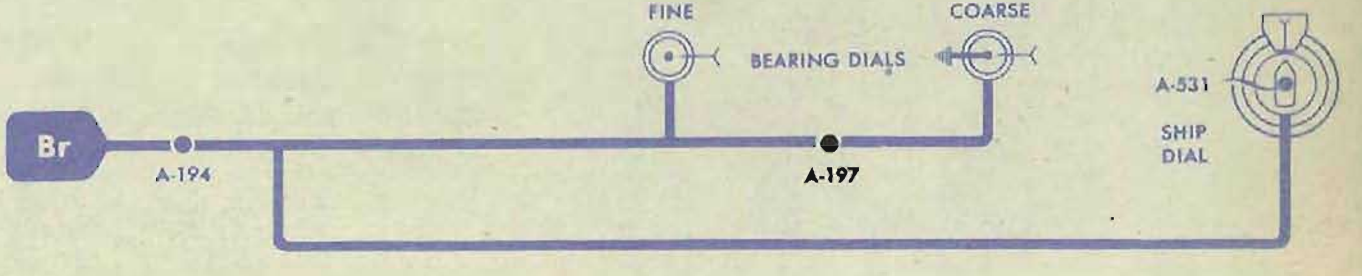
Set the ship dial and the fine *Br* dial at 0°.

The coarse *Br* dial should read 0°.

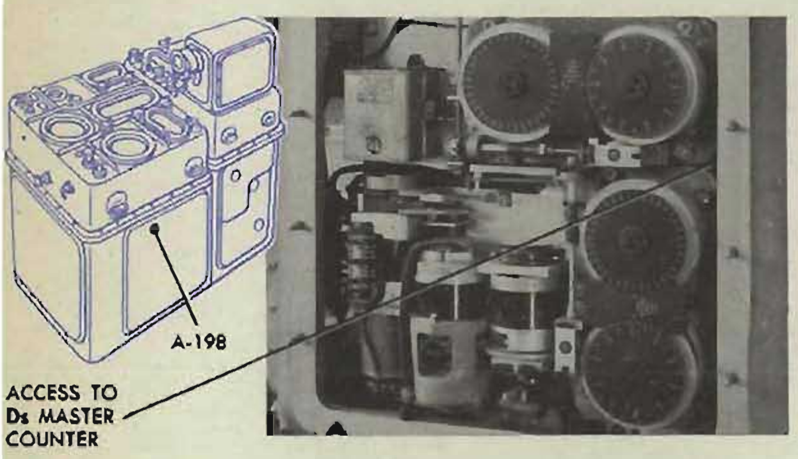
Adjustment

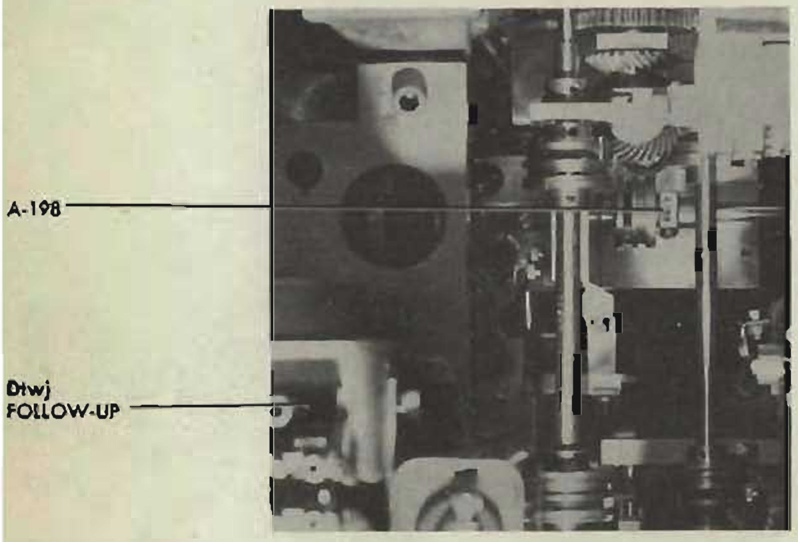
If the coarse *Br* dial does not read 0°, make A-197 slip-tight. Wedge the *Br* line. Slip the coarse dial to 0° by turning the meshing gear. Tighten A-197, and recheck.

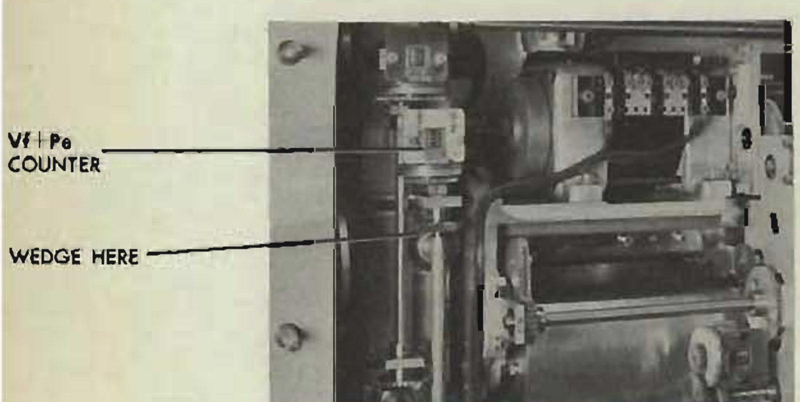
Check A-194 and A-531.



A-198 Ds MASTER COUNTER to L-28







Location

A-198 is under cover 5, to the rear of a coupling on a horizontal shaft.

The *Ds* master counter is under cover 8, behind the *B'gr* transmitter mounting plate.

L-28 is under cover 5, behind the *Dtwj* follow-up. It is in a vertical position with its upper limit at the top.

Check

The *Ds* master counter should read 9982 (−518 mils) at the lower limit, and 1018 (+ 518 mils) at the upper limit.

Turn the power OFF.

Set the *Vf+Pe* counter at 100 minutes (010) by turning the gearing to the counter under cover 4 at the top left, and wedge the line.

Set *I.V.* at 2550 f.s.

Increase *Ds* to the upper limit. The *Ds* counter should read 1018 mils.

Adjustment

If the *Ds* master counter does not read 1018 mils at the upper limit, loosen A-198.

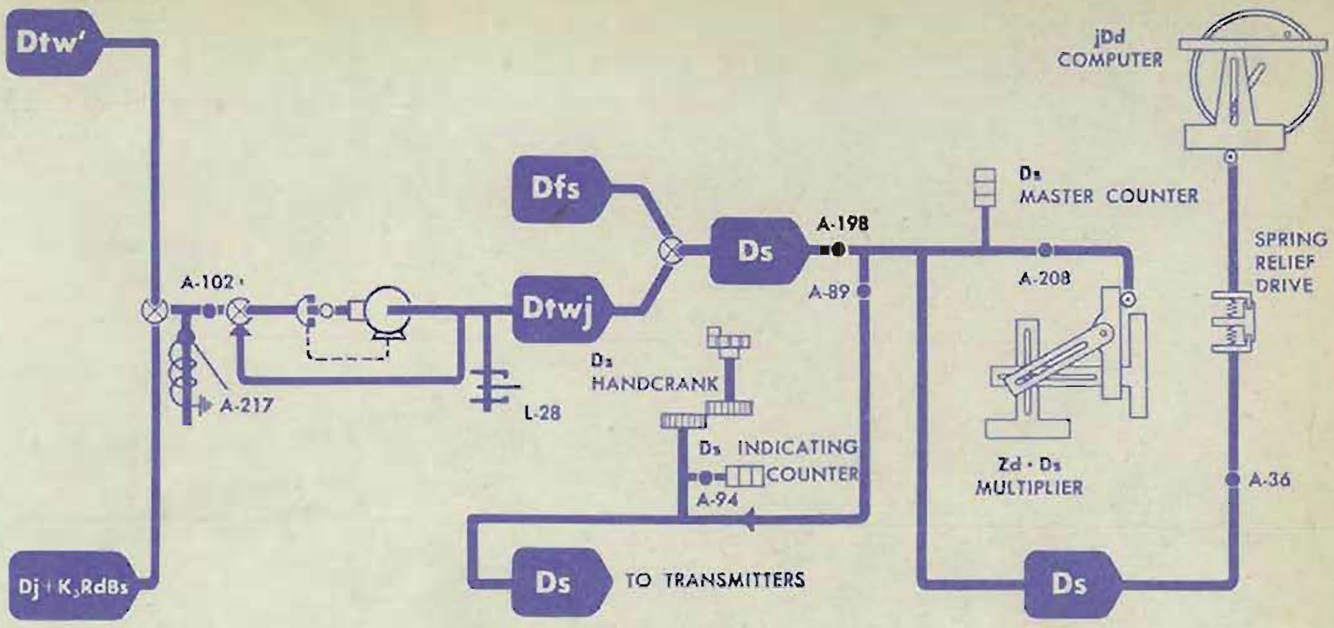
Wedge the *Dtwj* follow-up output gear against the limit. Turn the *Ds* handcrank until the *Ds* counter reads 1018 mils. Tighten A-198 and run *Ds* to its lower limit. The counter should read 9982.

IMPORTANT

If L-28 cannot be set at either limit, A-208 or A-36 may be causing a restriction. Loosen whichever clamp is interfering and readjust it later.

Remove the wedges from the *Dtwj* follow-up and the *Vf+Pe* line.

Check A-102, A-110 and A-105.

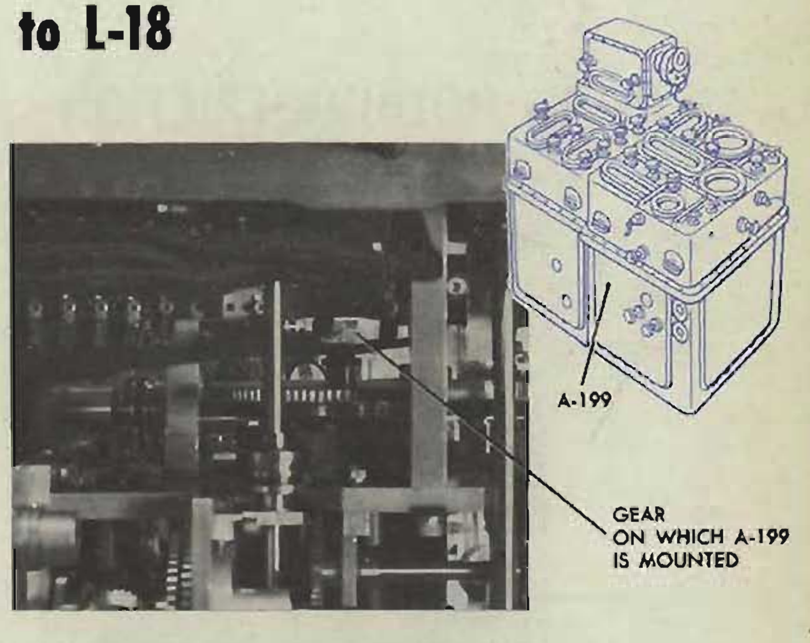


A-199 Br RING DIALS to L-18

Location

A-199 is under cover 3, on a horizontal shaft near the top plate, about 18 inches in toward the center.

L-18 is under cover 7, on the reverse side of the plate behind the output gearing of the *jB'r* follow-up motor. The upper limit is at the top.



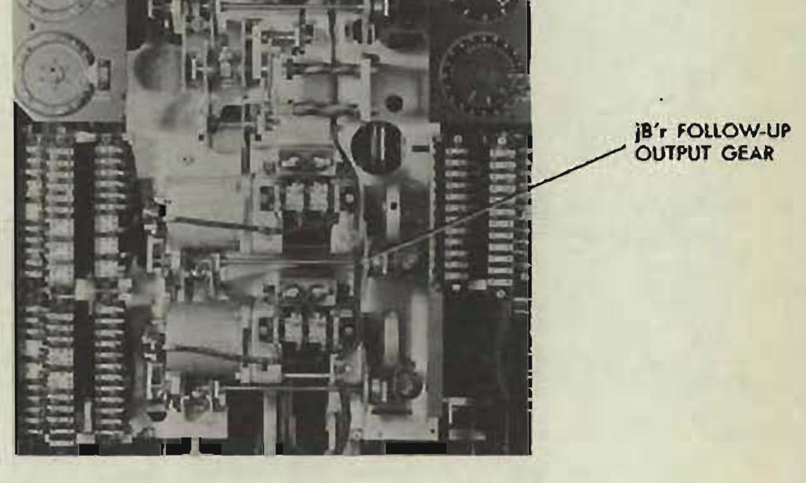
Check

Turn the power OFF.

Set *Dd* at 0° and wedge the line.
Set *B'gr* at 0° and wedge the line.
Turn the *jB'r* follow-up output gear until the upper limit of L-18 is reached.
The *Br* dials should read 11° 40'.

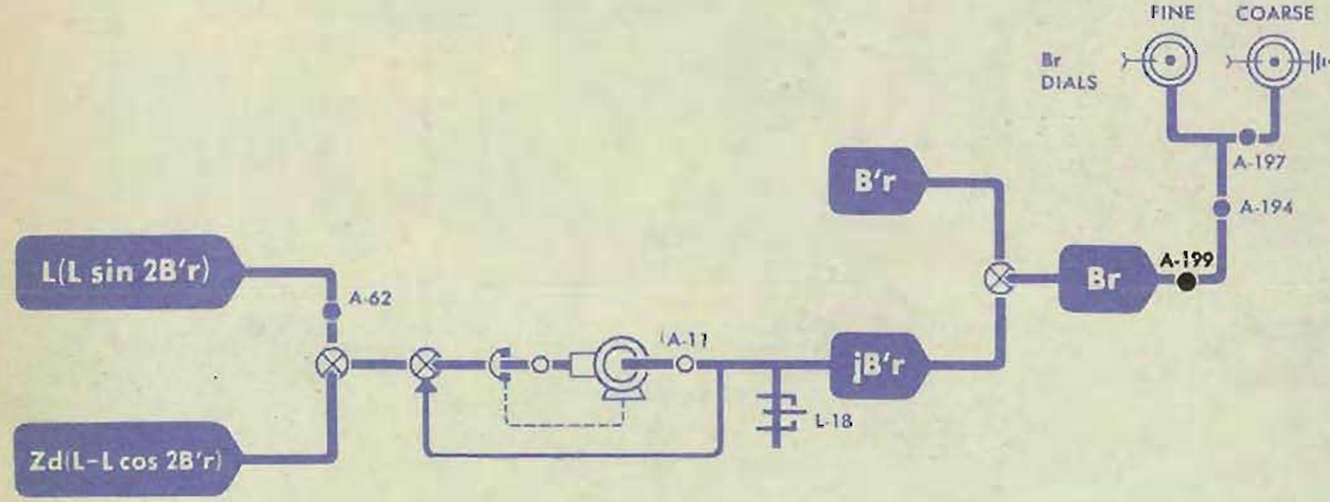
Adjustment

If the *Br* dials do not read 11° 40', hold *jB'r* against the stop. Loosen A-199. Use a gear pusher to turn the gear on which A-199 is mounted until the *Br* dials read their proper value. Tighten A-199, and recheck by running *jB'r* to the lower limit. The *Br* dials should read 348° 20'.

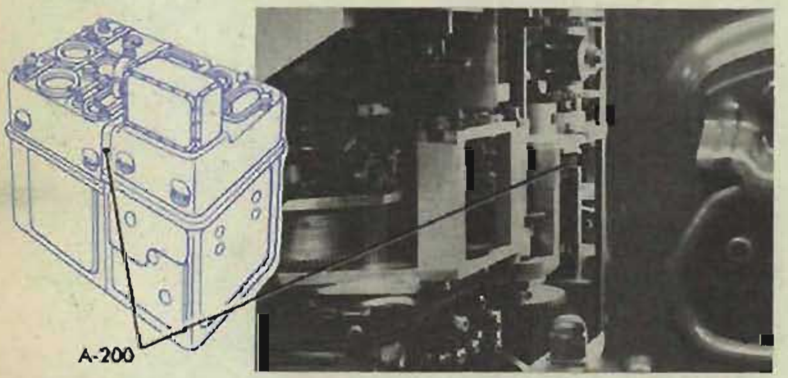


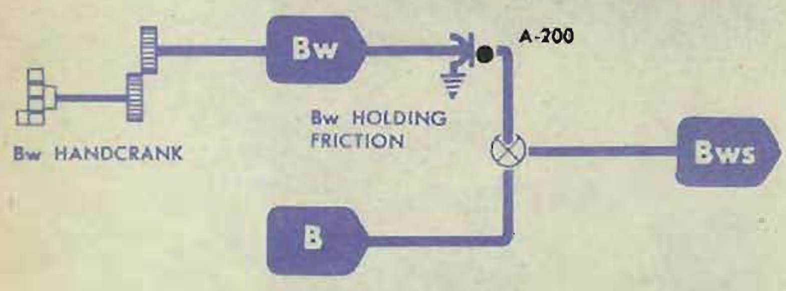
Remove the wedges from the *Dd* and *B'gr* lines.

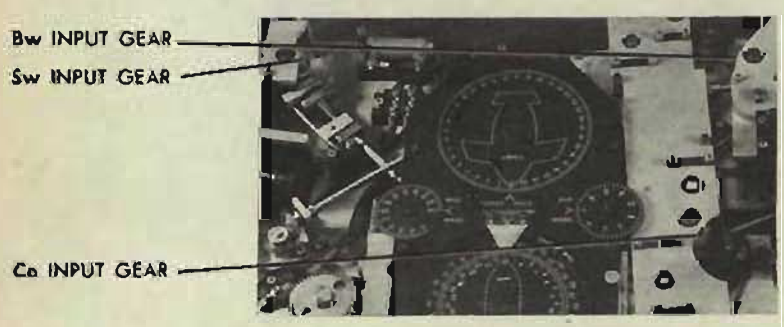
Check A-62.



A-200 Bw HOLDING FRICTION







Location

A-200 is under cover 1, at the right rear.

Check

The friction should hold the *Bw* setting without too much drag on the line.

Set *Sw* at 40 knots. Use the *Sw* input gear.

Turn the *Co* input gear.
There should be no motion of the *Bw* input gear.

Adjustment

If the *Bw* input gear moves, loosen A-200 and turn the clamp until there is enough friction to hold the setting.

Tighten A-200, and recheck.

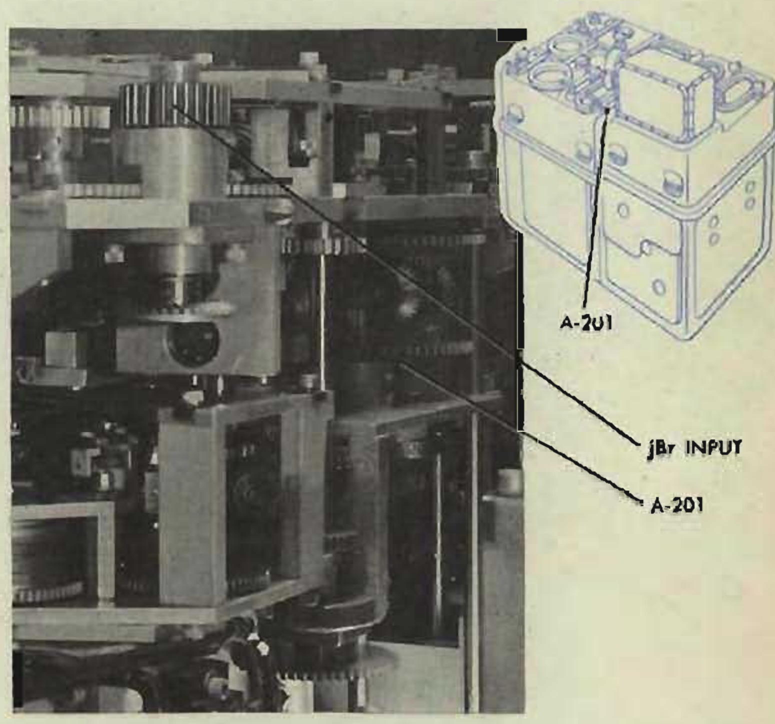
IMPORTANT

Increase the friction only to the point where no motion backs through *Bw*, and the *Bw* input gear still turns easily.

A-201 jBr HOLDING FRICTION

Location

A-201 is under cover 1, at the right rear.



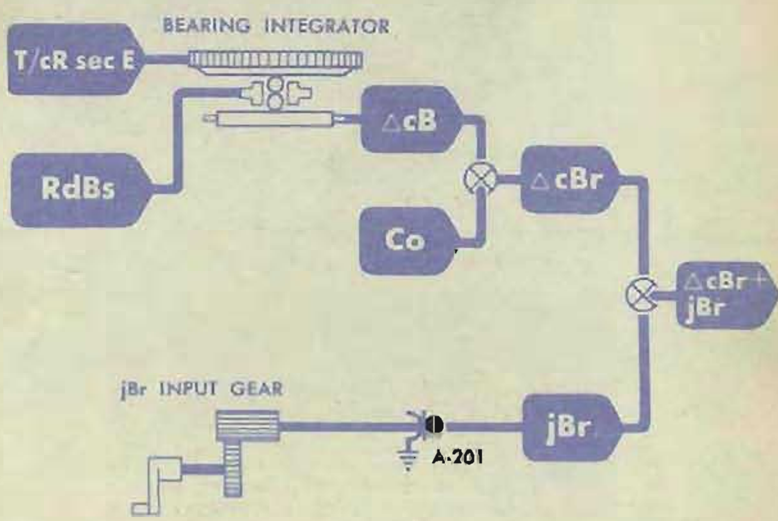
Check

This friction should hold the *jBr* setting without too much drag on the line.

Turn the power ON.
Turn the time motor ON.

Set *Br* at 0°.
Set *A* at 90° and wedge the line.

Increase *Sh* to 400 knots to offset the carriage of the bearing integrator. The integrator output should not back out the *jBr* input gear.

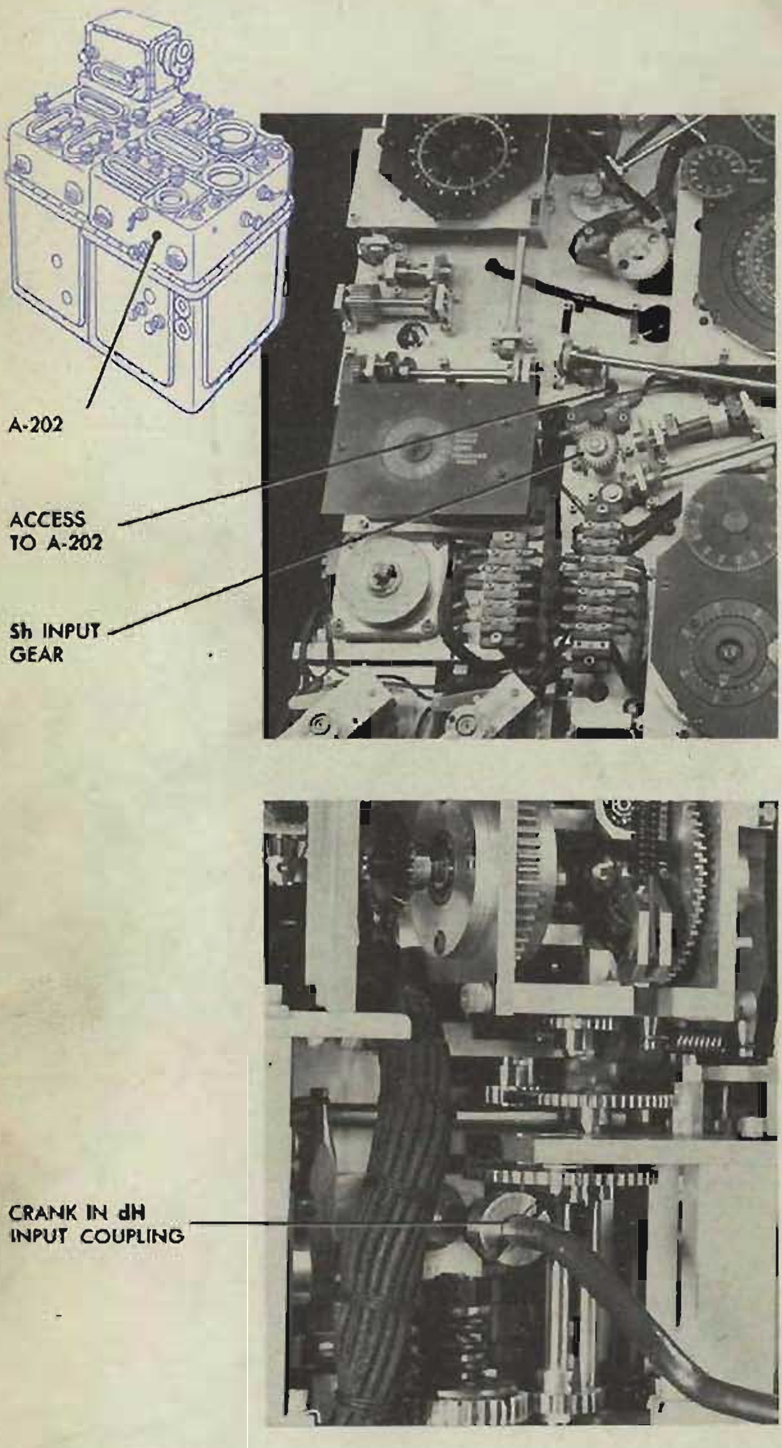


Adjustment

If any of the integrator output backs through the *jBr* input gear, loosen A-201 and turn the clamp clockwise to increase the friction.

Tighten A-201 and recheck.

A-202 dH FRICTION DRIVE



Location

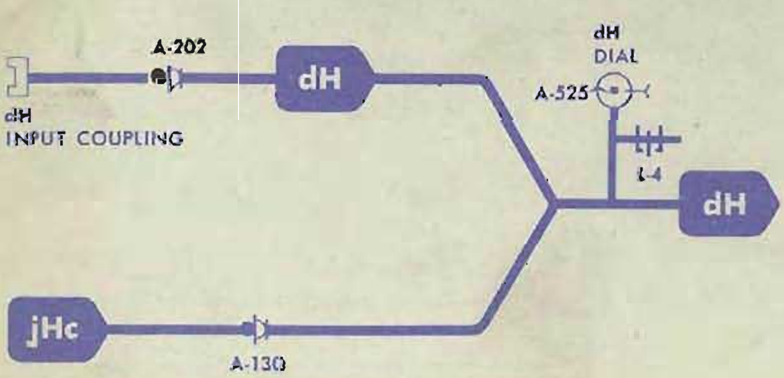
A-202 is under cover 1, on the end of the *dH* input shaft.

Check

A-202 should drive the *dH* line whenever an input is made manually. It should slip when the *dH* line runs against either end of the limit stop.

Turn *dH* rapidly for several revolutions, then slowly, then rapidly again. The *dH* dial should follow the movement of the handcrank closely, without slipping. If the dial moves erratically, the friction drive is too loose.

Run the line into the stop. The friction drive should slip without requiring the handcrank to be forced. If it does not slip with normal turning effort, the friction is too tight.



Adjustment

If the check shows that A-202 is out of adjustment, loosen the screw and turn the clamp clockwise to increase the friction, or counterclockwise to decrease it.

Tighten A-202, and recheck.

A-203 R3 COUNTER to R2 COUNTER

Location

A-203 is under cover 4, at the lower left of the fuze ballistic computer.

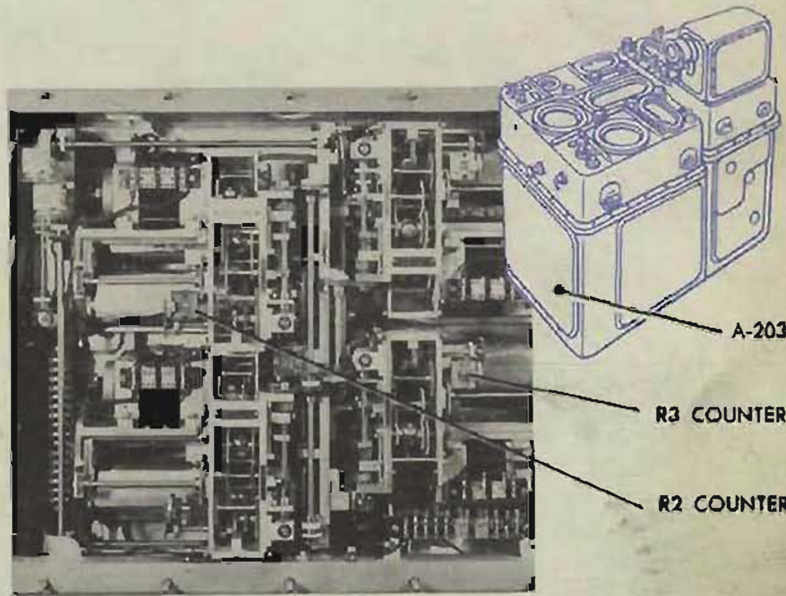
Check

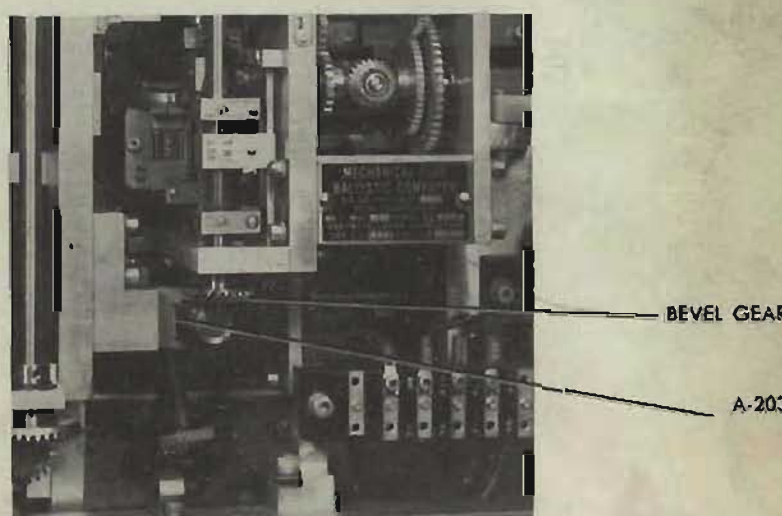
FOR SER. NOS. 780 AND LOWER:
Set *Tg* at 0 seconds.
Set *dR* at 0 knots.
The *R3* counter on the fuze ballistic computer should agree with the *R2* counter on the *Tf* ballistic computer.
FOR SER. NOS. 781 AND HIGHER:
Set *Tg* at 0 seconds.
Disconnect leads A and AA on the *Tf* follow-up, and leads D and DD on the *F* follow-up. Set *F* equal to *Tf*.
Turn the power ON.
Set *So*, *Sh*, and *dH* at 0 knots.
Put the *dR* handcrank at AUTO.
Set *I.V.* at 2550 f.s.
The *R3* counter on the fuze ballistic computer should agree with the *R2* counter on the *Tf* ballistic computer.
NOTE: Before readjusting A-203, check A-48 and A-47 on Ser. Nos. 780 and lower; check A-48 on Ser. Nos. 781 and higher.

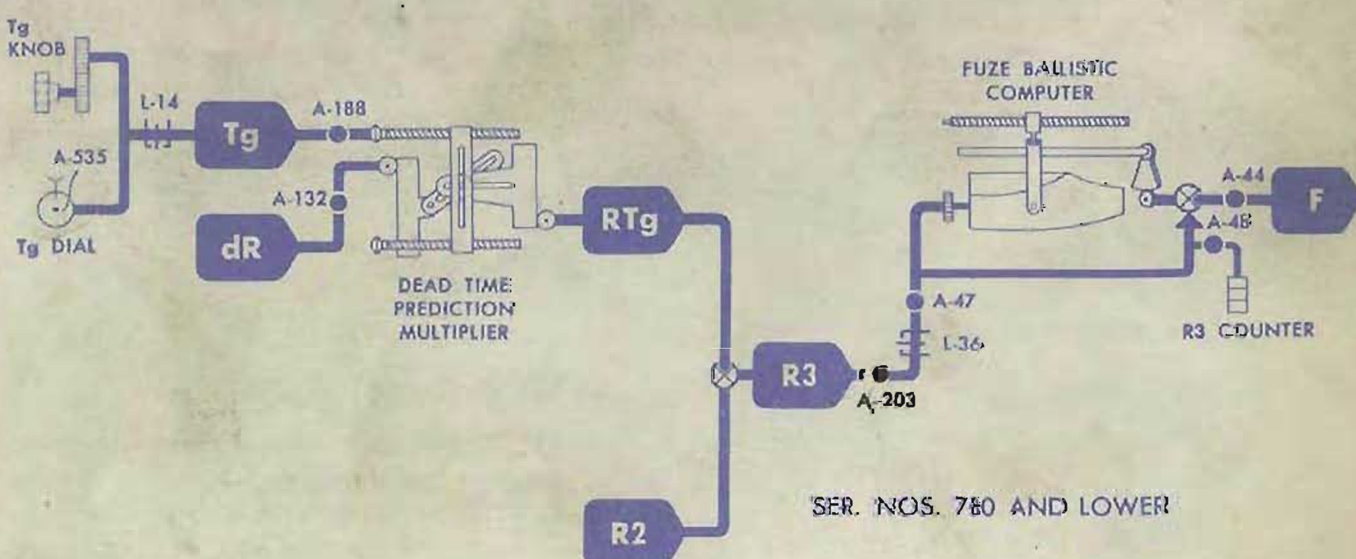
Adjustment

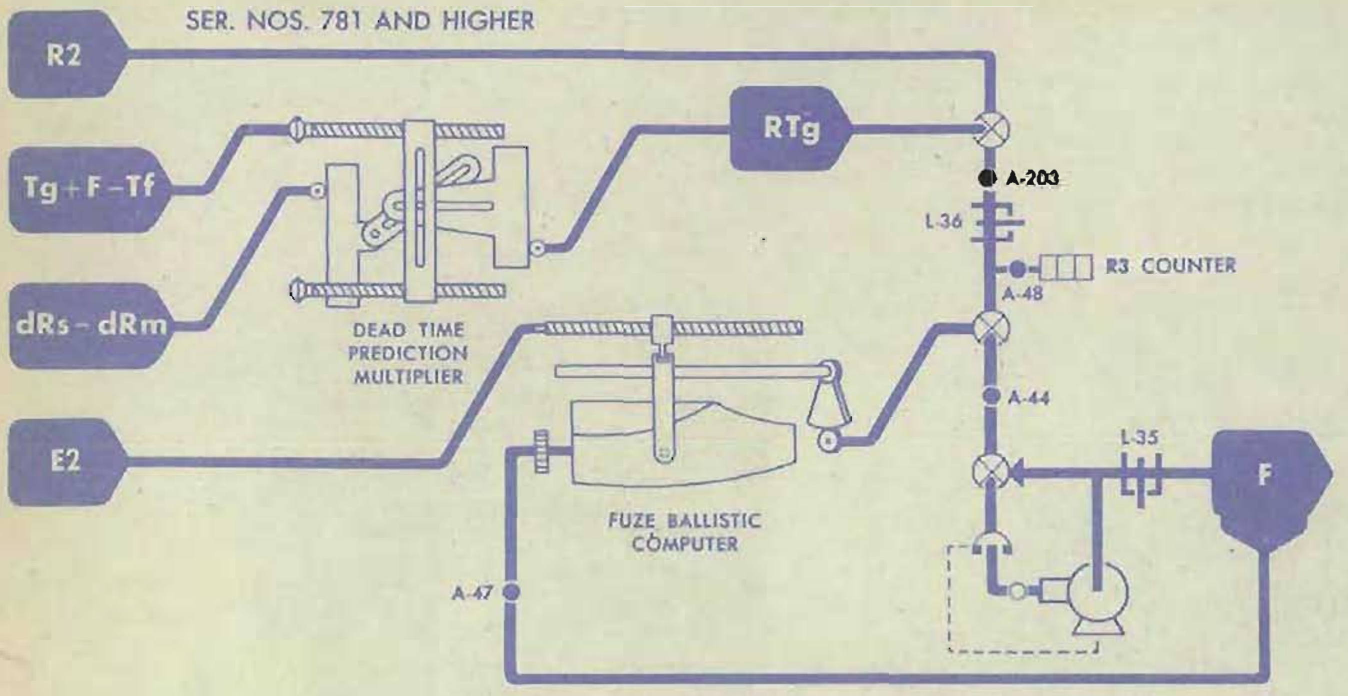
If the counters do not agree, make A-203 slip-tight. Turn the bevel gear in front of A-203 until the *R3* counter reads the same as the *R2* counter.

Tighten A-203, and recheck.

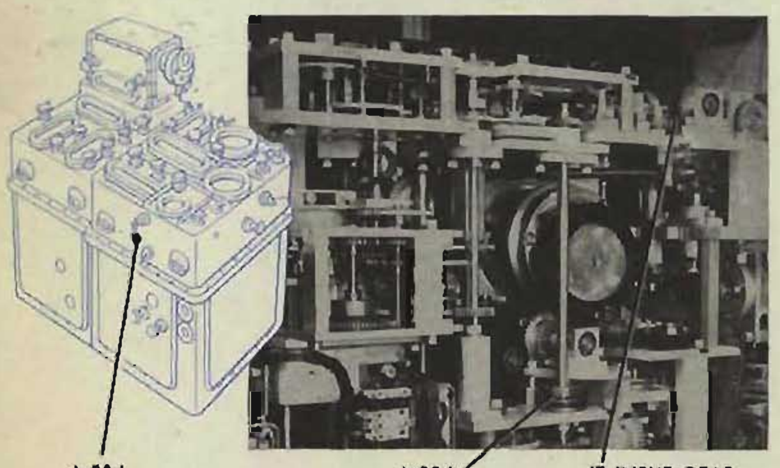


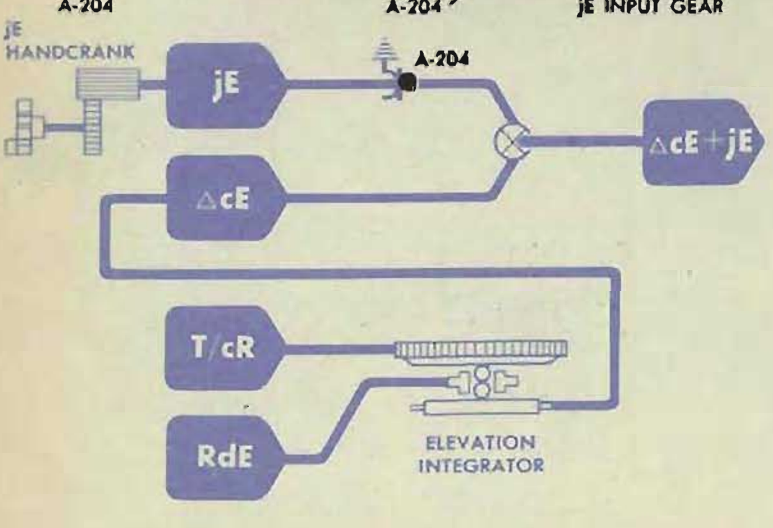






A-204 jE HOLDING FRICTION





Location

A-204 is under cover 1, at the left.

Check

A-204 should hold the *jE* setting without too much drag on the line.

Turn the time motor ON.

Set *E* at 0° and increase *dH* to +150 knots to offset the carriage of the elevation integrator. The integrator roller output should not back out the *jE* input gear.

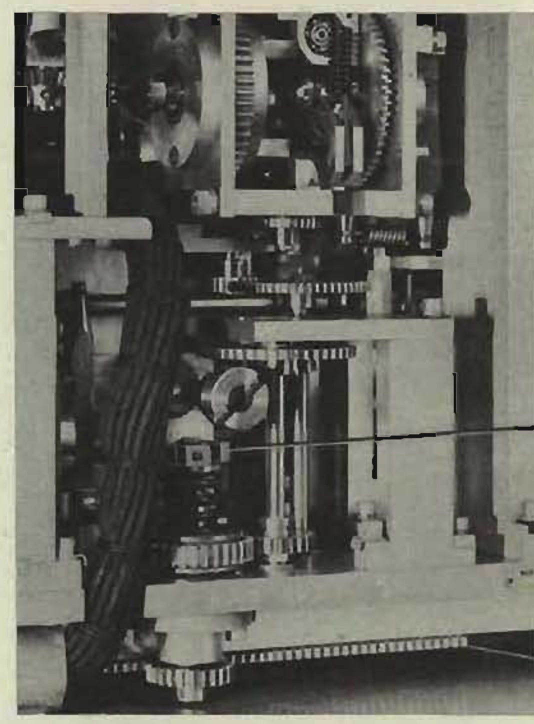
Adjustment

If A-204 is not properly adjusted, loosen the screw and turn the clamp clockwise to increase the friction. Tighten the screw, and recheck.

A-205 VECTOR SOLVER FRICTION DRIVE

Location

A-205 is under cover 1, at the left center.

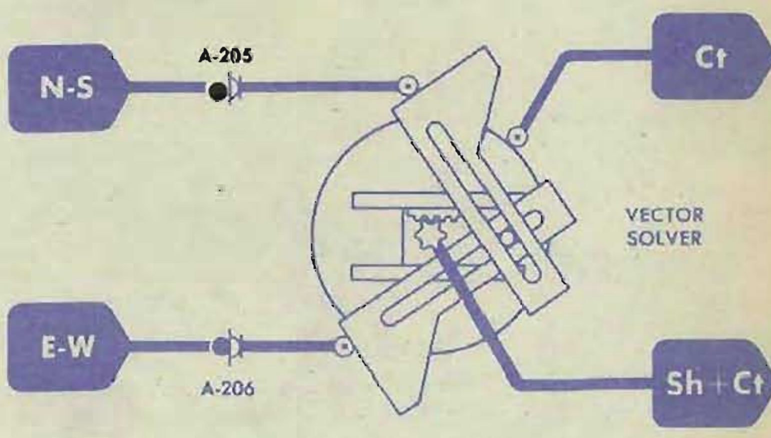


Check

This friction should be tight enough to allow the N-S line to drive the N-S rack and position the vector solver during rate control. It should slip, however, when *Sh* or *Ct* is introduced manually.

Adjustment

Loosen A-205 and turn the threaded clamp until it barely touches the washer below it. Then turn the clamp clockwise 3½ turns, thereby compressing the spring. Tighten the screw and recheck.



Note

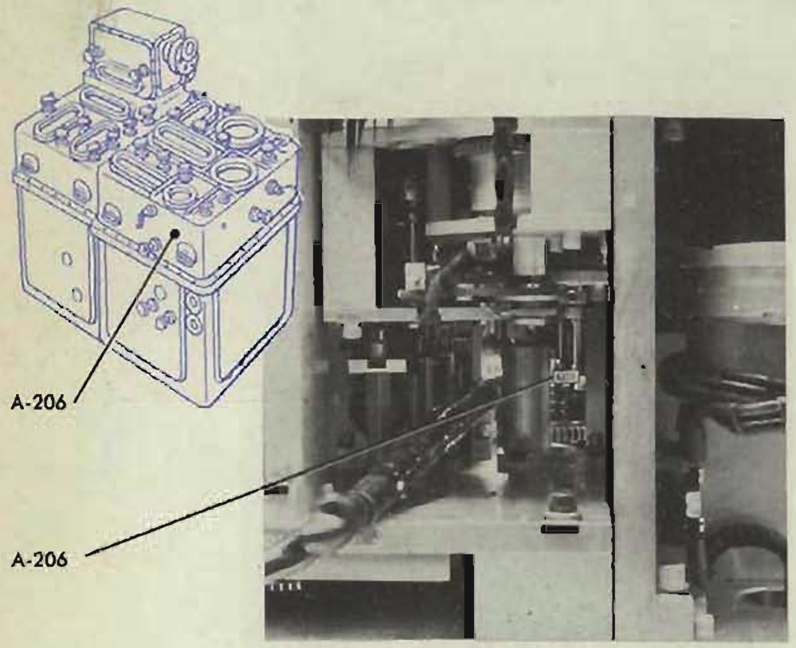
The friction loads on A-205 and A-206 should be equal.

CONTENTS

VOLUME ONE

VOLUME TWO

A-206 VECTOR SOLVER FRICTION DRIVE



Location

A-206 is located under cover 1, at the front of the vector solver.

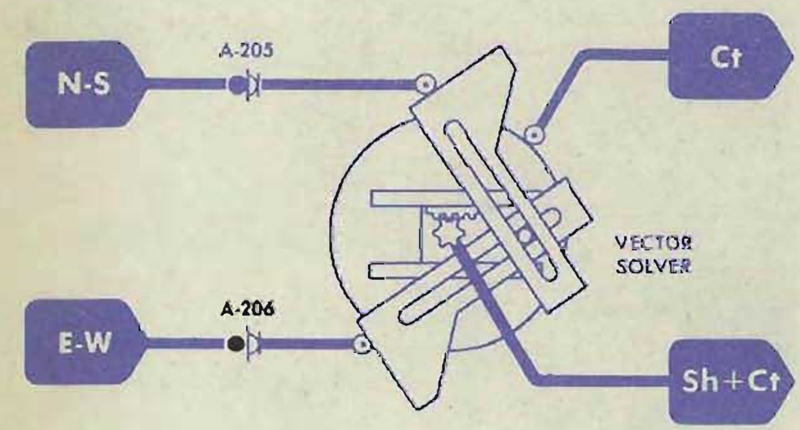
Check

This friction should be tight enough to allow the E-W line to drive the E-W rack and position the vector solver during rate control. It should slip, however, when *Sh* or *Ct* is introduced manually.

Adjustment

Loosen A-205 and turn the threaded clamp until it barely touches the washer below it. Then turn the clamp clockwise 3½ turns, thereby compressing the spring.

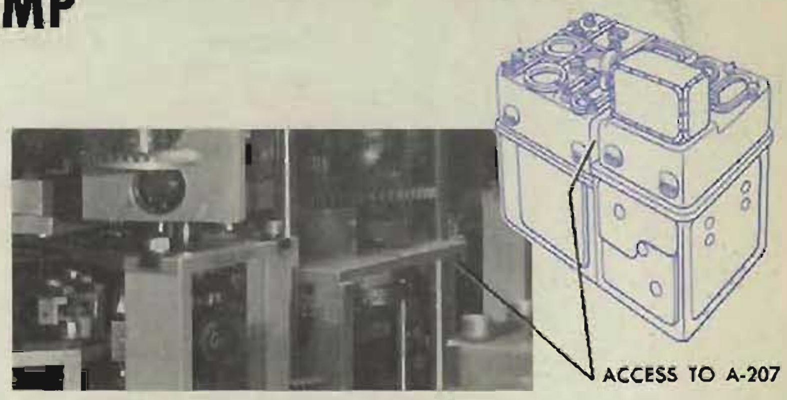
Tighten the screw, and recheck.



Note

The friction loads on A-206 and A-205 should be equal.

A-207 ASSEMBLY CLAMP

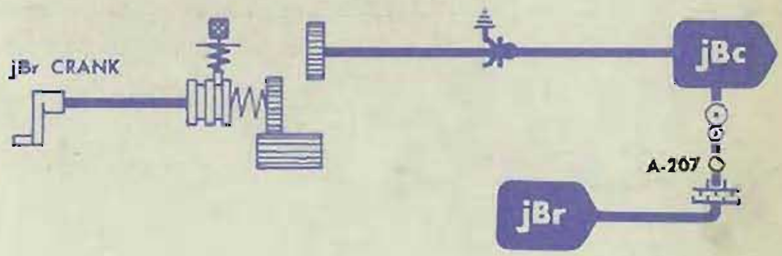


Location

A-207 is under cover 1 at the rear, on the spur gear of the *jBr* clutch.

Check

A-207 should be tight.



Adjustment

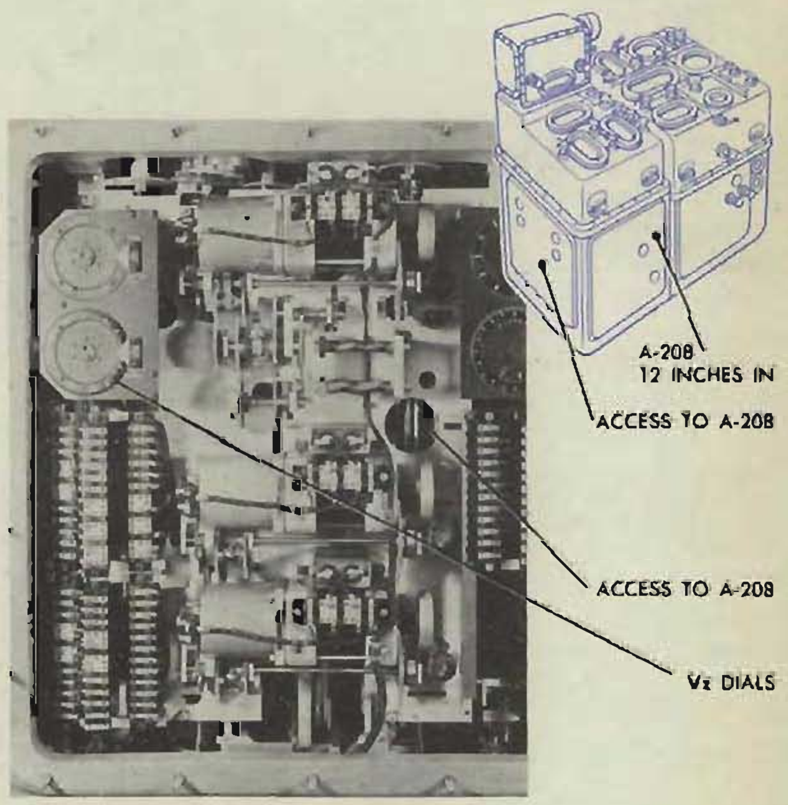
Tighten A-207. No further adjustment is necessary.

A-208 Zd·Ds MULTIPLIER to Ds COUNTER

Location

A-208 is under cover 8. It can be reached through the access hole above the damper of the *jB'r* follow-up, under cover 7.

Older instruments do not have this access. On these computers, A-208 may be adjusted with a geared screw driver inserted under cover 8.



Check

Turn the power ON.

Set *Ds* at 500 mils.
Set *Vs* at 2000'.
Set *L* at 2000'.
Set *E* at 0' with the sync *E* handcrank at CENTER.
Match the sync *E* dials at the fixed index with the handcrank OUT.

Full travel of *Zd* should cause no motion of the output rack of the *Zd·Ds* multiplier.

Motion of the *Zd·Ds* output rack can be observed on the *Vz* dials. The dials should not move for full travel of *Zd*.

Adjustment

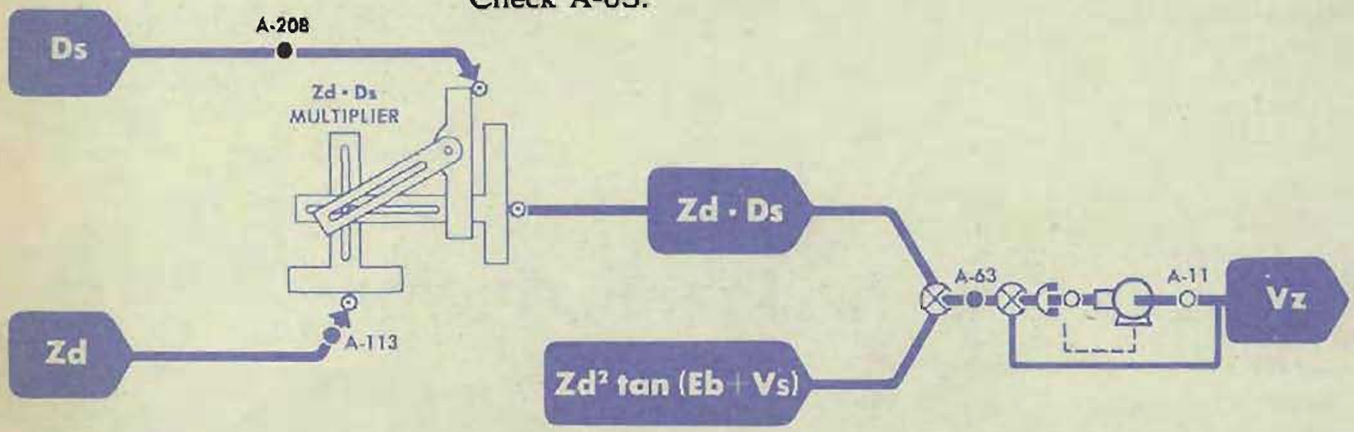
If the *Vz* dials move, make A-208 slip-tight.

CAUTION

While making A-208 slip-tight, hold the *Ds* input rack to prevent its falling and causing damage.

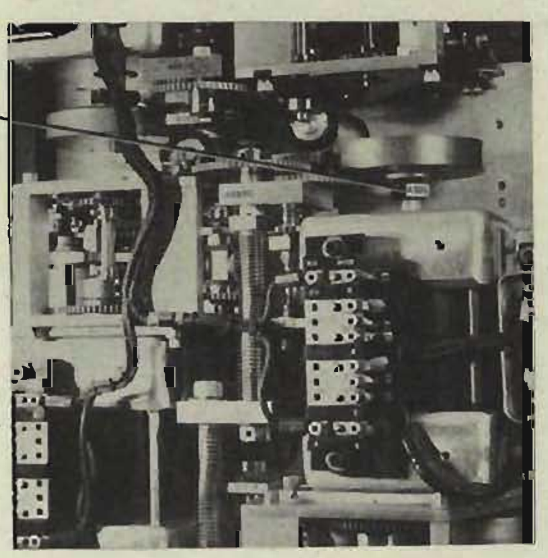
Offset *Ds* to locate the zero position of the *Ds* input rack. When there is no motion of the *Vz* dials for full travel of *Zd*, hold the small spur gear on the same shaft as A-208, and bring the *Ds* counter back to 500 mils with the handcrank.

Tighten A-208, and recheck.
Check A-63.



A-209 ASSEMBLY CLAMPS

A-209



TYPICAL LOCATION OF A-209 ON DAMPER OF R2 FOLLOW-UP UNDER COVER 5

Location

A-209 is the assembly clamp that holds each magnetic damper to its associated servo shaft. There is a magnetic damper and a clamp A-209 on each of the following servo motor shafts:

Under cover 1: *RdE, dRh, RdBs, dR, Sh, Ct, jdR, jE, jBr*

Under cover 3: *WrD + KRdBs*

Under cover 4: *F, Tf, Vf + Pe, Tf/R2*

Under cover 5: *Ywgr, R2, V, Dtwj, Co*

Under cover 6: *Eb, Eb* booster

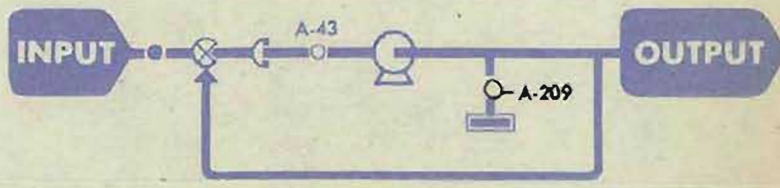
Under cover 7: *Dd, Vz, jB'r, B'r* local control

Under cover 8: *B'r* receiver

A-209 is also located on the large damper on the bearing filter under cover 3.

Check

If A-209 is loose, the damping action of the damper is lacking, and the damper may slip along the shaft to cause interference with other assemblies. A follow-up with a loose damper may oscillate or come to a slow stop, after wandering back and forth past the synchronizing point. Check that A-209 is tight and the damper is located so that it causes no interference with any part of the mechanism.



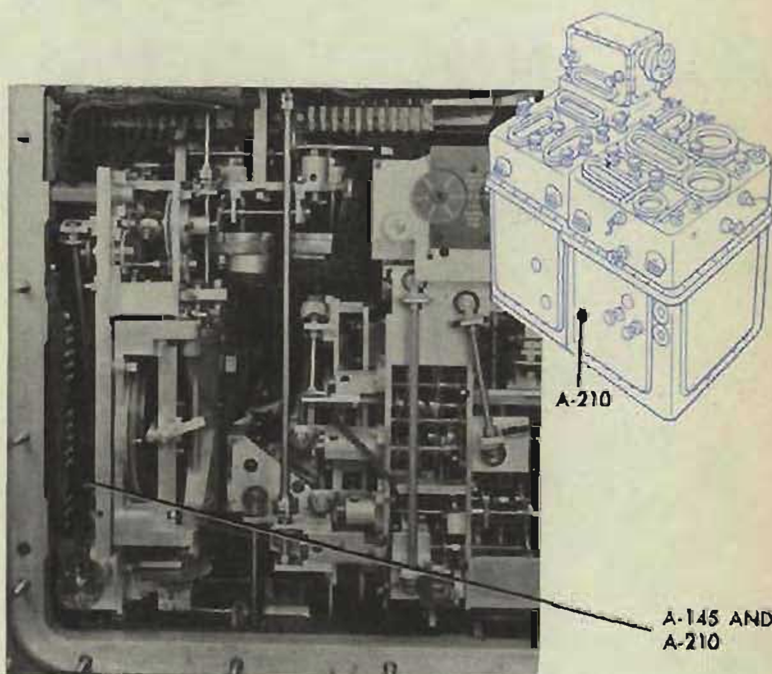
Adjustment

Tighten A-209.

A-210 SECANT E CAM to E DIALS

Location

A-210 is under cover 3, behind the integrator mounting plate. A-210 is on computers with Ser. Nos. 389 and lower. It is replaced by A-146 on Ser. Nos. 390 and higher.

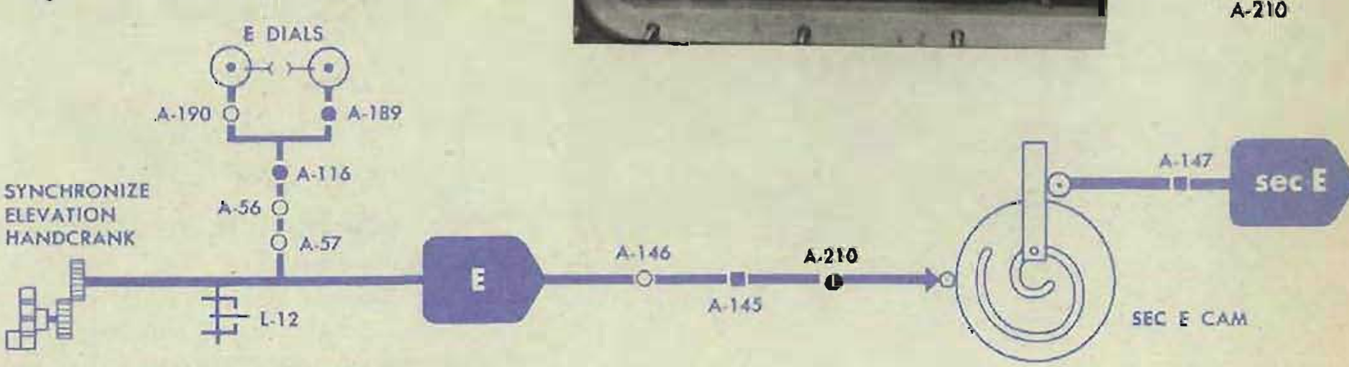


Check

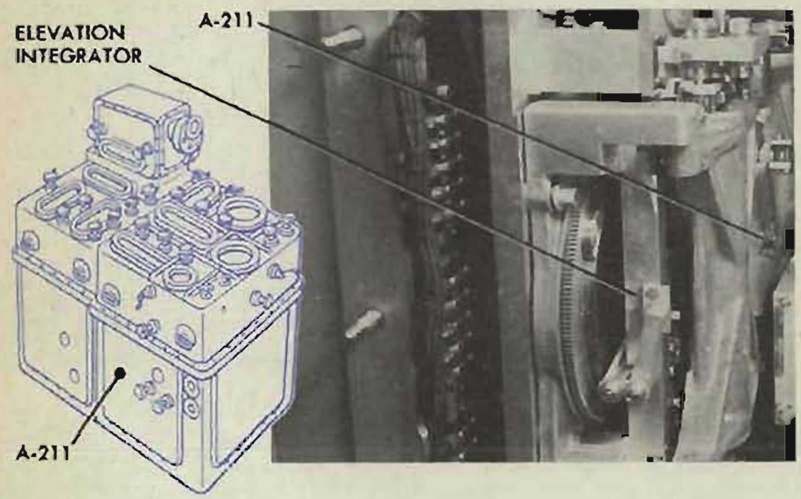
Check that A-210 is tight, and A-145 is in adjustment.

Adjustment

Follow the readjustment procedure for A-146.
Tighten A-210, and readjust A-145.



A-211 ASSEMBLY CLAMP



Location

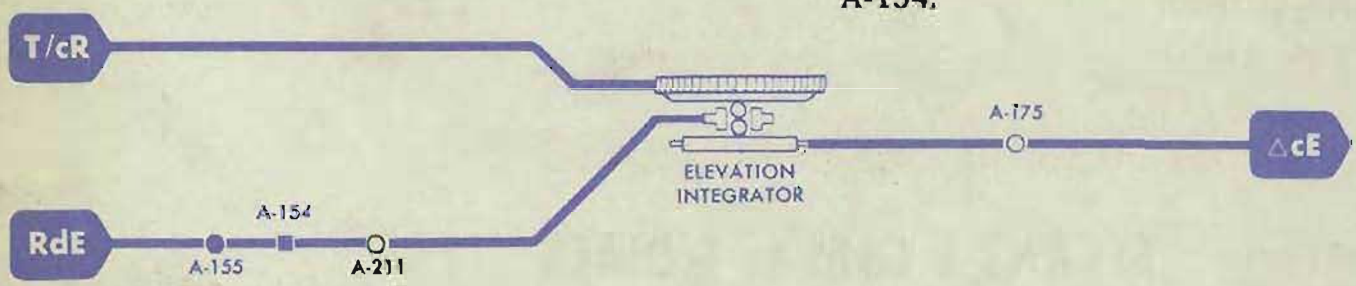
A-211 is under cover 3, on a large spur gear near the elevation integrator.

Check

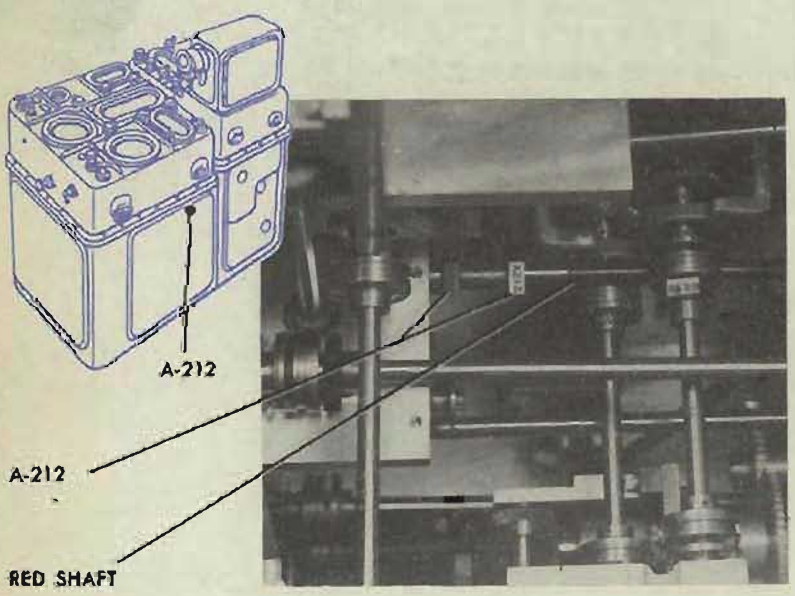
A-211 should be tight enough to prevent the elevation integrator carriage from slipping through the clamp to move off its setting.

Adjustment

Tighten A-211. Readjust A-155 and A-154.



A-212 So DIAL to So RECEIVER



Location

A-212 is under cover 5, about 14 inches in, on the front end of a red shaft.

A-212 is a sleeve coupling with a clamp on either end.

A-212 is omitted on Mod 0.

Check

Turn *So* from limit to limit with the *So* handcrank IN, to make sure that the *So* limit-stop adjustment is not upset.

Shift the *So* handcrank to the OUT position.

Turn the power ON.

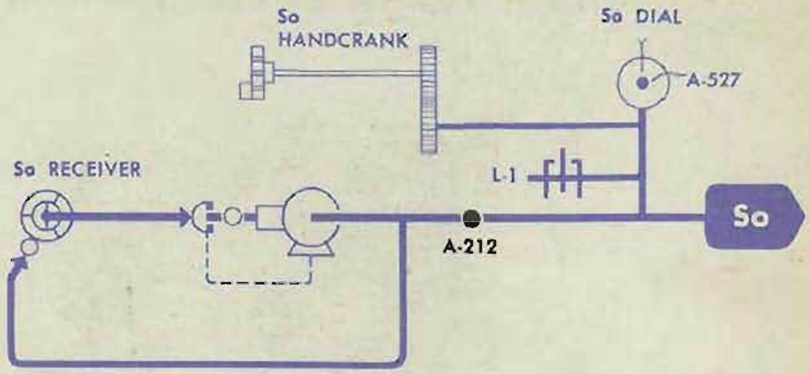
Transmit *So* from the pitometer log to the computer.

The *So* dial should read the same value as that being transmitted from the pitometer log.

Adjustment

If the *So* dial does not match the pitometer log value, loosen A-212. Bring the *So* dial to the matching value, with the *So* handcrank IN. Shift the handcrank to the OUT position. The *So* dial should stay at the correct value. If it does not, shift the handcrank to the IN position and correct until it does.

Tighten A-212 and check *So* transmission at two or three different values.



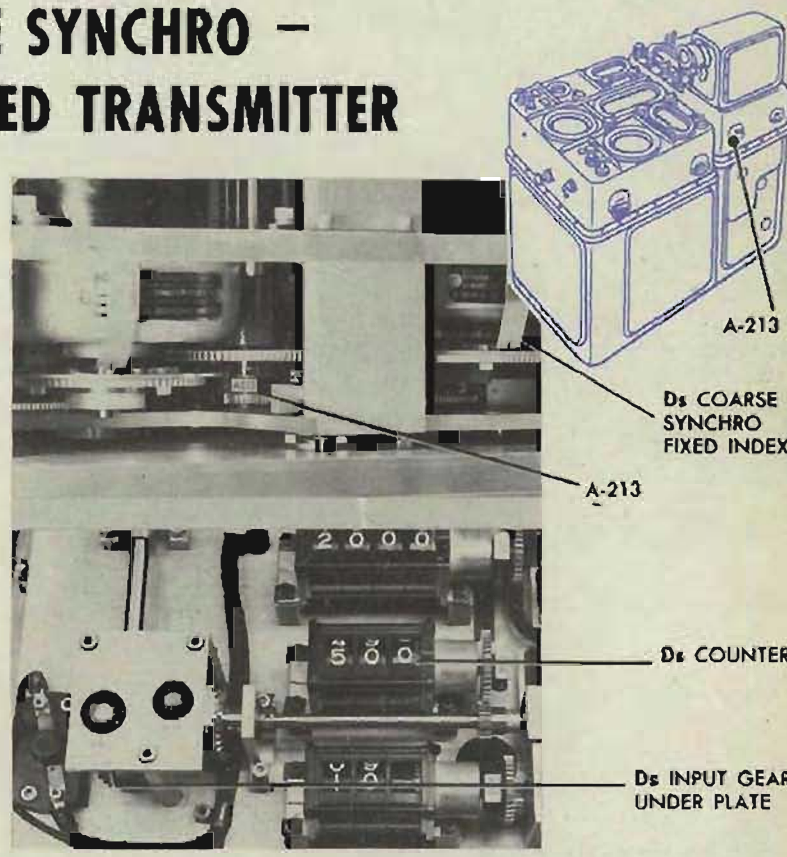
Note

Both clamps A-212 on the sleeve coupling must be tight.

A-213 COARSE to FINE SYNCHRO – Ds DOUBLE-SPEED TRANSMITTER

Location

A-213 is under cover 2.
It is omitted on Mods 0, 2, and 6.



Check

Set the coarse *Ds* synchro at electrical zero, using the *Ds* input gear.

The fine *Ds* synchro should also be at electrical zero.

Both synchros are at electrical zero when the scribe marks on their rotors are matched with the fixed index marks.

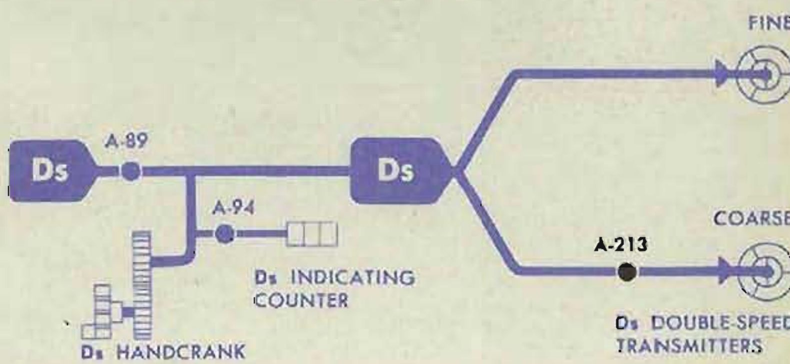
Adjustment

If the fine synchro is not at electrical zero, make A-213 slip-tight.

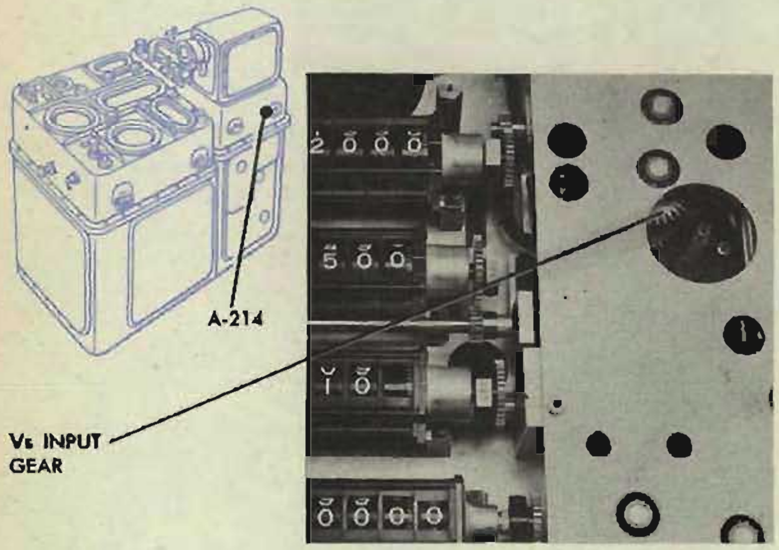
Hold the large gear on the rotor of the coarse synchro.

Turn the *Ds* input gear until the fine synchro is at electrical zero.

Tighten A-213 and recheck.



A-214 COARSE to FINE SYNCHRO — Vs DOUBLE-SPEED TRANSMITTER



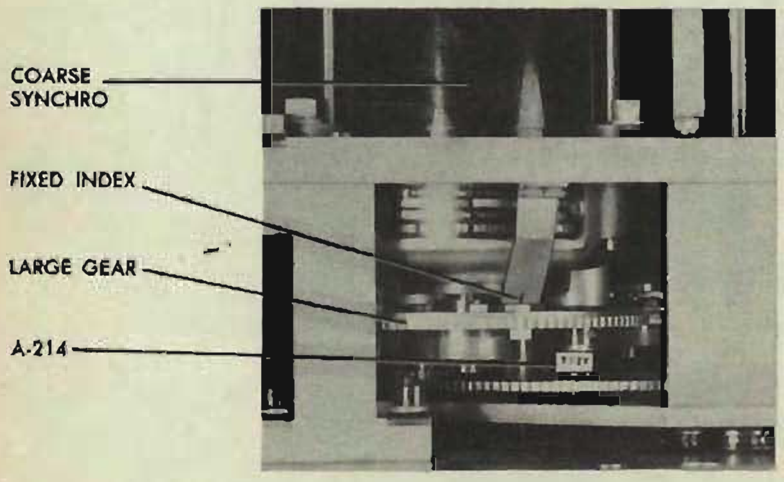
Location

A-214 is under cover 2, below and to the right of the fine *Vs* synchro. A-214 is omitted on Mods 0, 2, and 6.

Check

Set the coarse *Vs* synchro at electrical zero, using the *Vs* input gear.

The fine *Vs* synchro should also be at electrical zero. Both synchros are at electrical zero when the scribe marks on their rotors are matched with the fixed index marks.



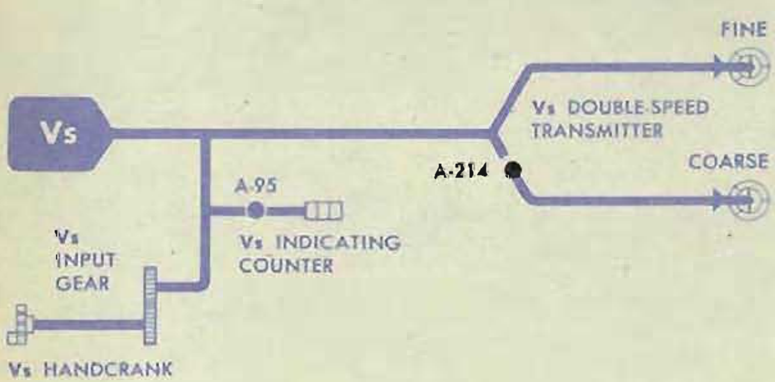
Adjustment

If the fine synchro is not at electrical zero, make A-214 slip-tight.

Hold the large gear, which meshes with the gear above A-214, to keep the coarse synchro at electrical zero.

Turn the *Vs* input gear until the fine synchro is at electrical zero.

Tighten A-214 and recheck.



A-215 LOST MOTION TAKE-UP SPRING on jDd LINE

Location

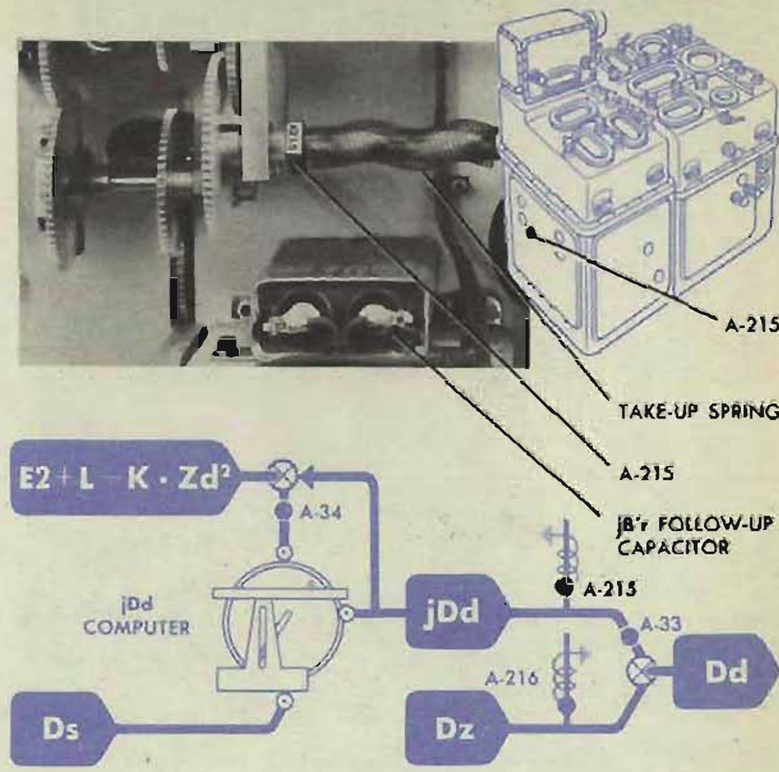
A-215 is under cover 7, above the *jB'r* follow-up capacitor.

Adjustment

Turn the power ON.
Set *Ds* at 500 mils.

Loosen the clamp and allow the spring to unwind.
Wind the spring three revolutions by turning the clamp.

Tighten the screw.
Check A-33.



A-216 LOST MOTION TAKE-UP SPRING on Dz LINE

Location

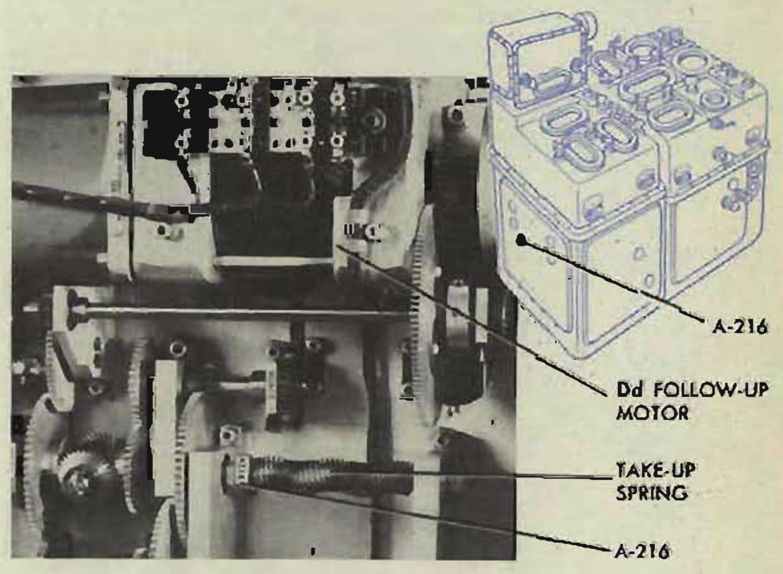
A-216 is under cover 7, at the end of the spring 2 inches below the *Dd* follow-up.

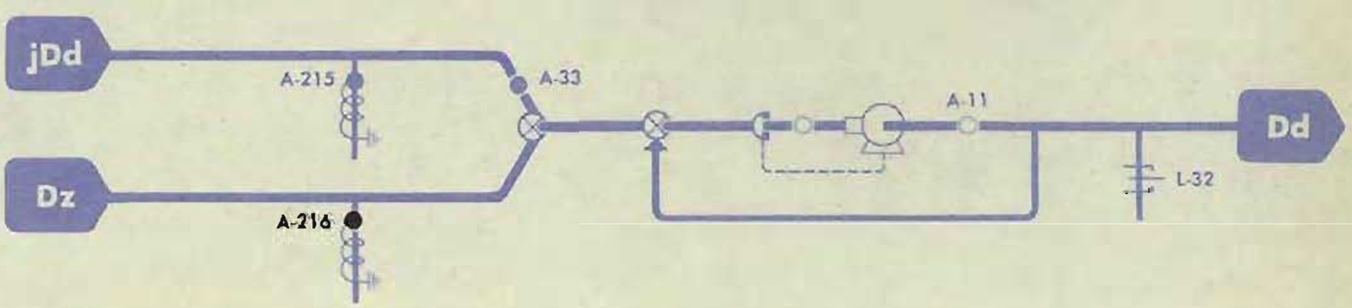
Adjustment

Turn the power ON.
Set *Zd* at 2000'.

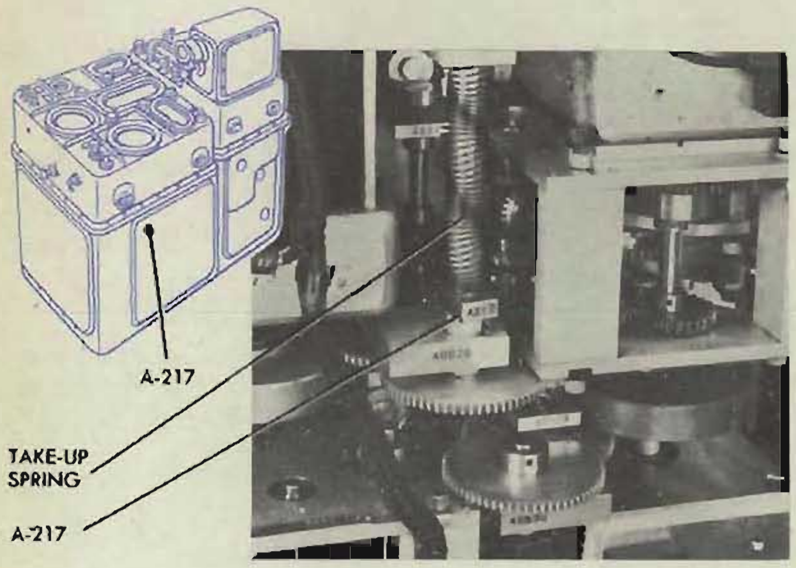
Loosen the clamp and allow the spring to unwind.
Wind the spring three revolutions by turning the clamp.

Tighten the screw.
Check A-33.





A-217 LOST MOTION TAKE-UP SPRING on Dtwj LINE



Location

A-217 is under cover 5.

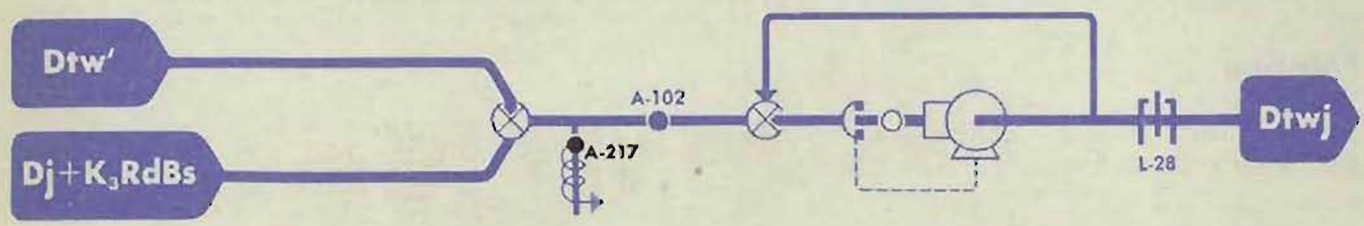
Adjustment

Turn the power ON.
Set *So*, *Sh*, *Sw*, and *Dj* at 0.

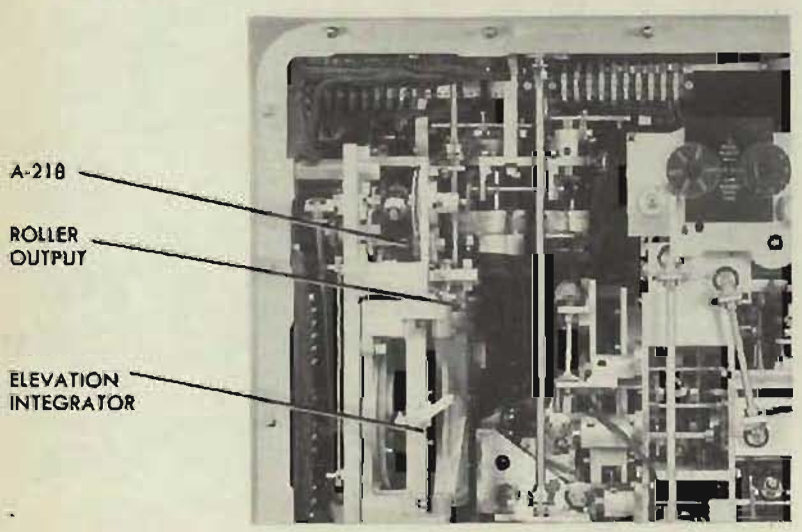
Loosen the clamp and allow the spring to unwind.

Wind the take-up spring three revolutions counterclockwise (looking down) by turning the clamp.

Tighten A-217.
Check A-102.



A-218 ASSEMBLY CLAMP



Location

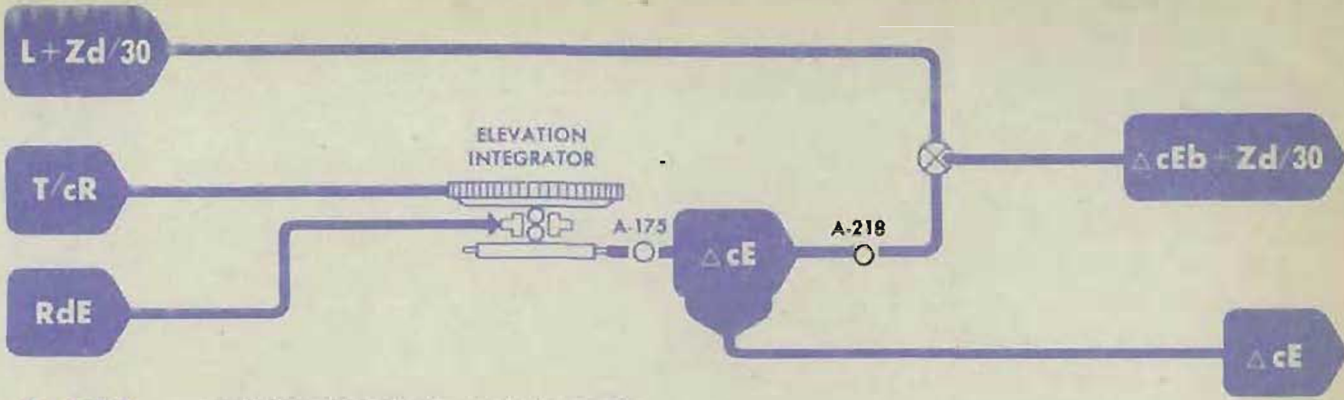
A-218 is under cover 3, on a spur gear in the output gearing of the elevation integrator.
A-218 is omitted on Mod 0.

Check

Check that A-218 is tight.

Adjustment

Tighten A-218.



A-219 ASSEMBLY CLAMP

Location

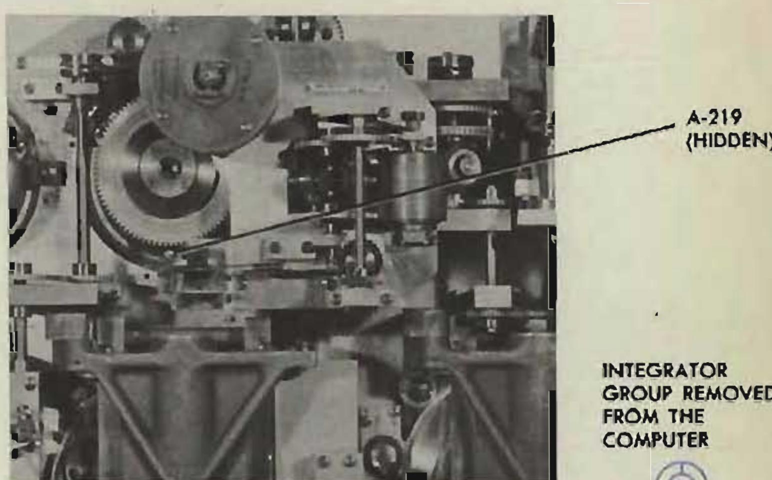
A-219 is under cover 3, above the sec *E* integrator, on the △*cB′r* gearing. A-219 is omitted on Mod 0.

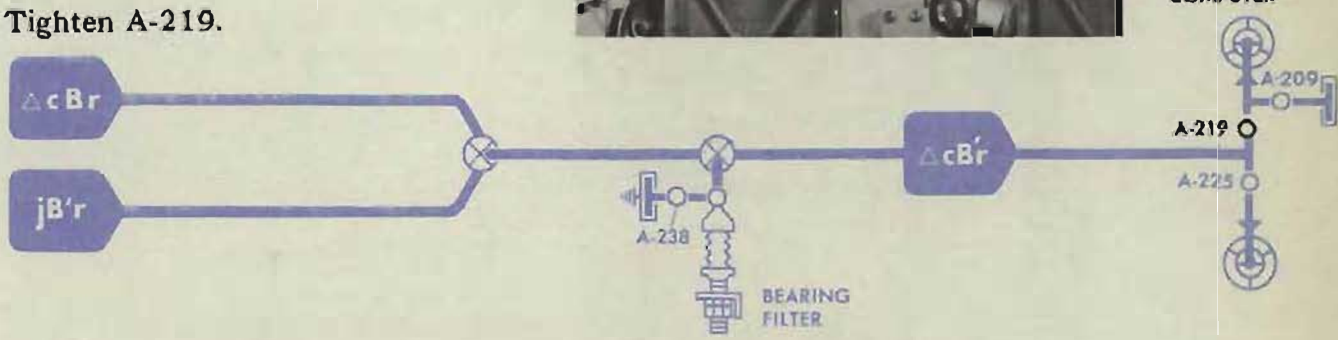
Check

Check that the △*cB′r* auto transmitter rotor gear cannot be turned when the △*cB′r* line is held.

Adjustment

Tighten A-219.





A-220 LOST MOTION TAKE-UP SPRING on R2 LINE

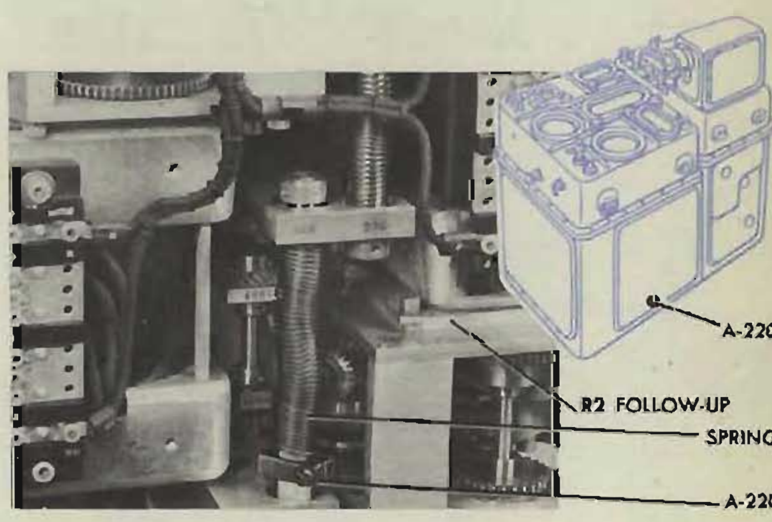
Location

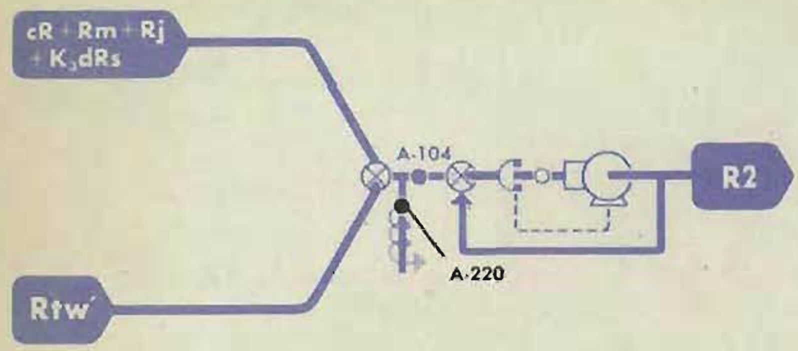
A-220 is under cover 5, in front of the *R2* follow-up control.

Adjustment

Turn the power ON.
Set *So*, *Sh*, *Sw*, and *dH* at 0 knots.
Set *Rj* at 0 yards.
Set *I.V.* at 2550 f.s.
Set *cR* at 2000 yards.

Loosen the clamp and allow the spring to unwind.

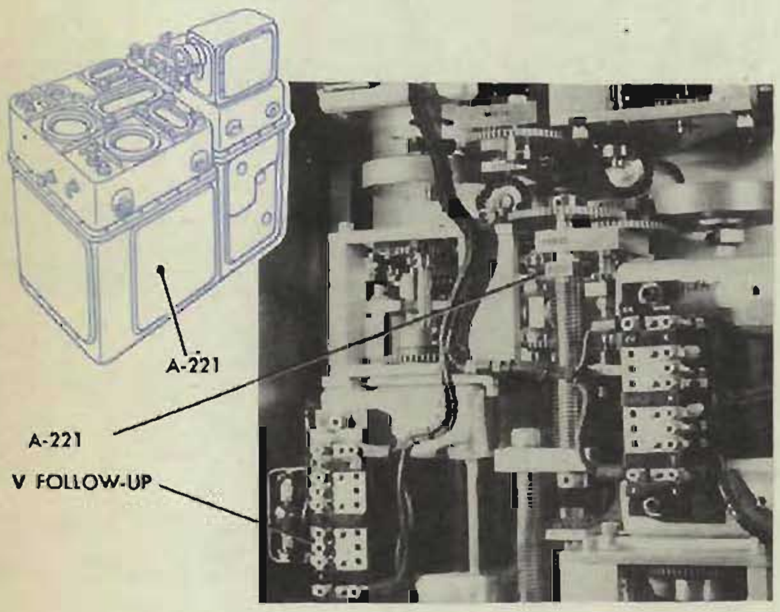




Wind the take-up spring three revolutions counterclockwise (looking down) by turning the clamp.

Tighten the screw.
Check A-104.

A-221 LOST MOTION TAKE-UP SPRING on V LINE



Location

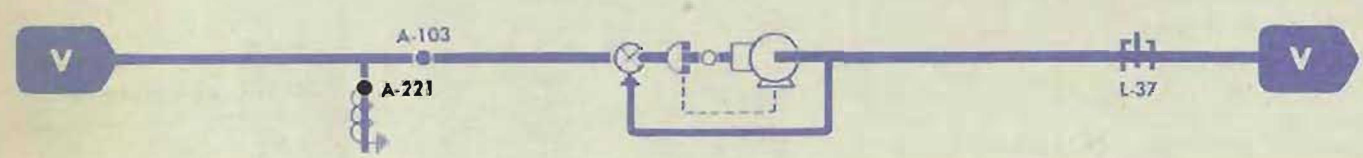
A-221 is under cover 5, at the upper end of the spring near the *V* follow-up.

Adjustment

Turn the power ON.
Set *So*, *Sh*, *Sw*, and *dH* at 0 knots.
Set *Ds* at 500 mils and *Vj* at 0 mils.

Loosen the clamp and allow the spring to unwind.
Wind the take-up spring three revolutions clockwise (looking down) by turning the clamp.

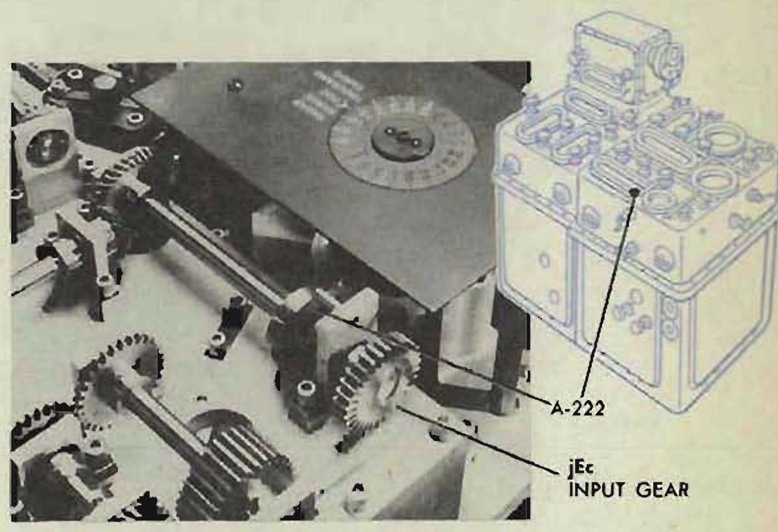
Tighten A-221.
Check A-103.



A-222 jEc HOLDING FRICTION

Location

A-222 is under cover 1, at the top left.



Check

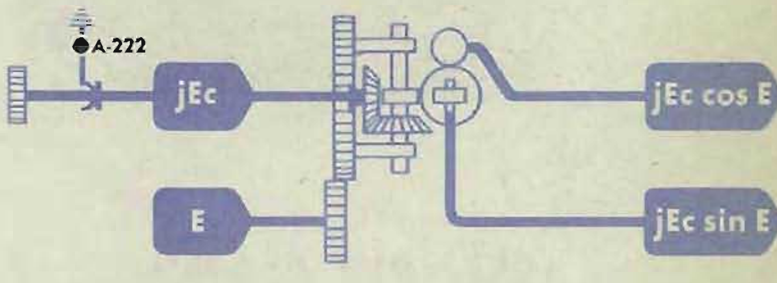
This friction should hold the *jEc* setting without too much drag on the line.

Set *E* at 45°.
Introduce rapid range rate corrections into the rate control group.
No motion of *jdR* should back through the *jEc* line.

Adjustment

If any motion of *jdR* moves the *jEc* input gear, loosen A-222 and turn the clamp clockwise to increase the friction.

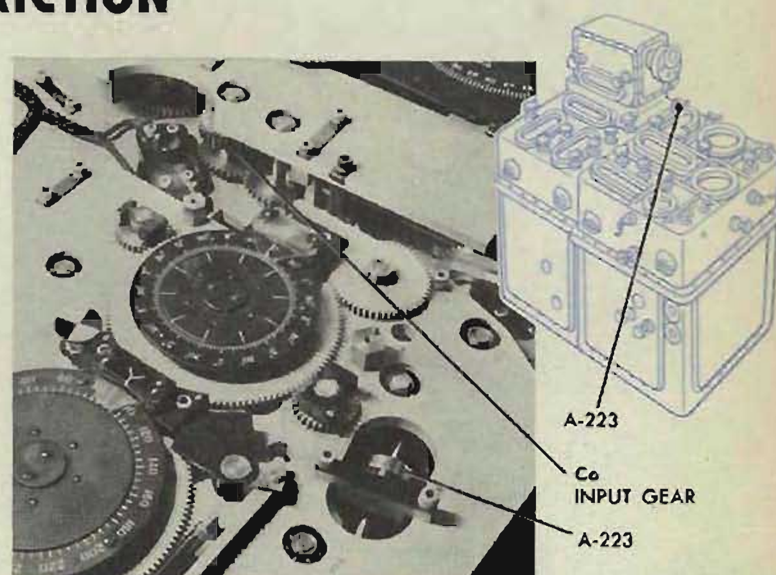
Tighten A-222, and recheck.



A-223 jBc HOLDING FRICTION

Location

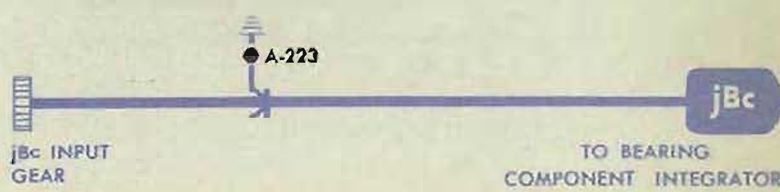
A-223 is under cover 1. It can be reached through the access hole to the rear of the fine *Br* dial.

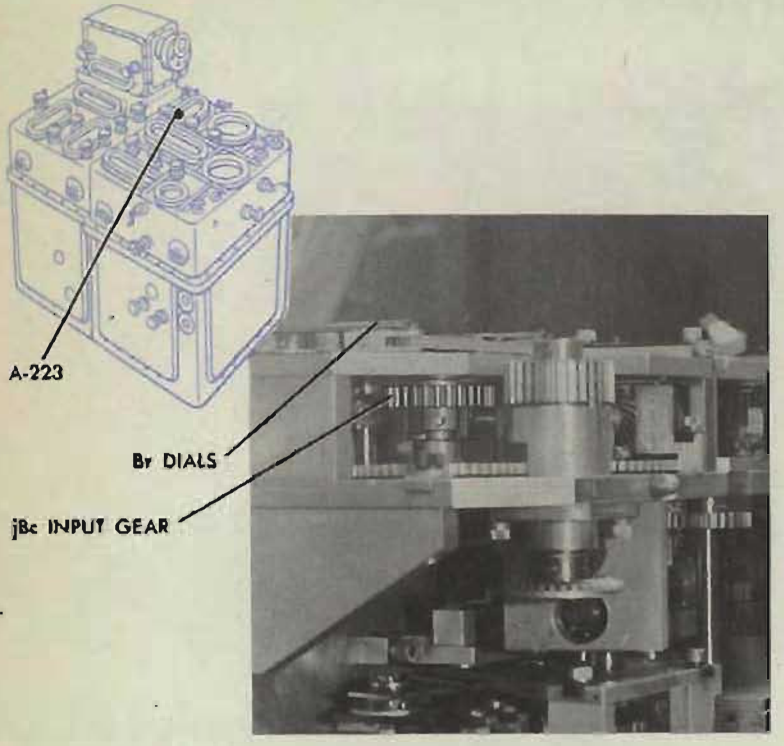


Check

This friction should hold the *jBc* setting without too much drag on the line.

Set *B* at 45°.
Set *E* at 0°.
Introduce rapid range rate corrections into the rate control group.
No motion of *jdRh* should back through the *jBc* line.



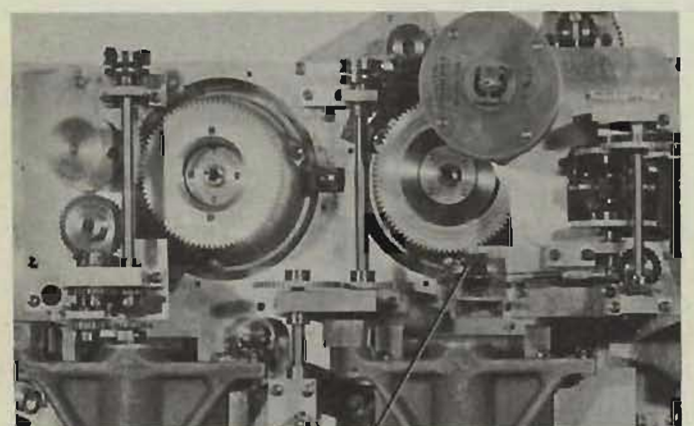


Adjustment

If the *jBc* input gear moves, loosen A-223 and turn the clamp clockwise to increase the friction.

Tighten A-223 and recheck.

A-225 ASSEMBLY CLAMP



INTEGRATOR ASSEMBLY REMOVED FROM INSTRUMENT

Location

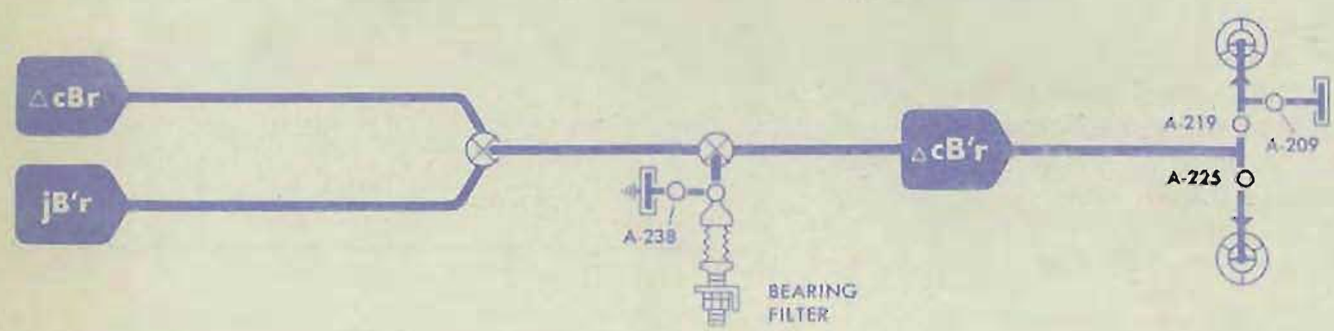
A-225 is under cover 3, on the same shaft as A-219.
It is omitted on Mod 0.

Check

Check that the $\Delta cB'r$ indicating transmitter rotor gear cannot be turned when the $\Delta cB'r$ line is held.

Adjustment

Tighten A-225.

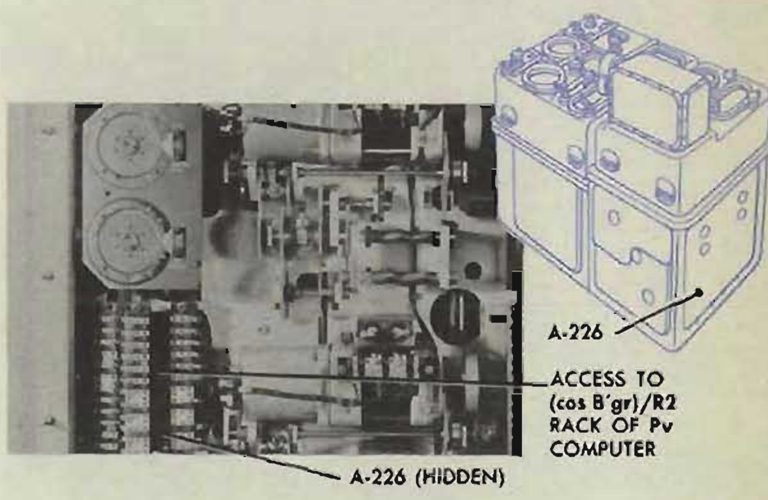


A-226 Pv COMPUTER to PARALLAX COMPONENT SOLVER

Location

A-226 is under cover 7, directly behind terminal 131.
A-226 is omitted on Mods 0-4, 6, 9, and 10.

The (cos *B'gr*)/*R2* rack of the *Pv* computer is below A-226.



Check

Turn the power OFF.

Set *Dd* at 0° and wedge the line.

Set *B'gr* at 90° and wedge the line.
Set *R2* at 18,000 yards.
The (cos *B'gr*)/*R2* rack of the *Pv* computer should be at its zero position.
Turn *E2* from 0° to 85°.
The *Pv* dial should not move.

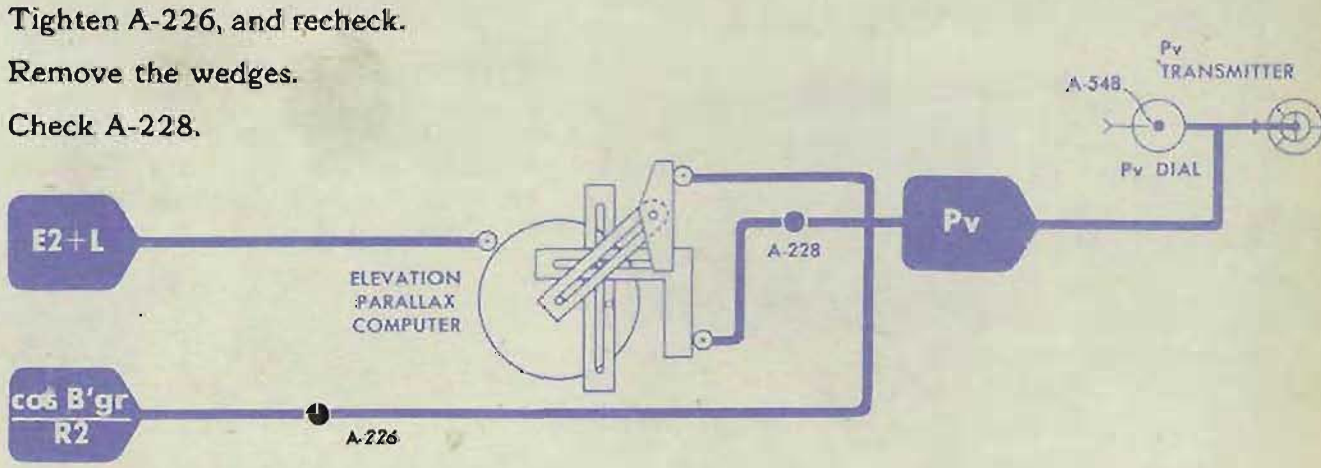
Adjustment

If the *Pv* dial moves, make A-226 slip-tight. Use a gear pusher to move the (cos *B'gr*)/*R2* input rack until its zero position is found. This will be the position where full travel of *E2* causes no motion of *Pv*.

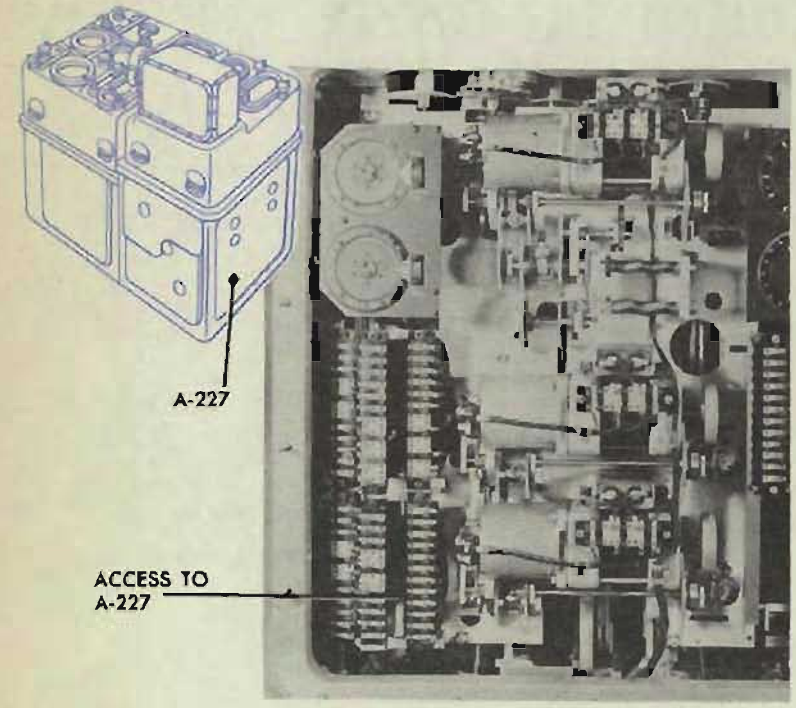
Tighten A-226, and recheck.

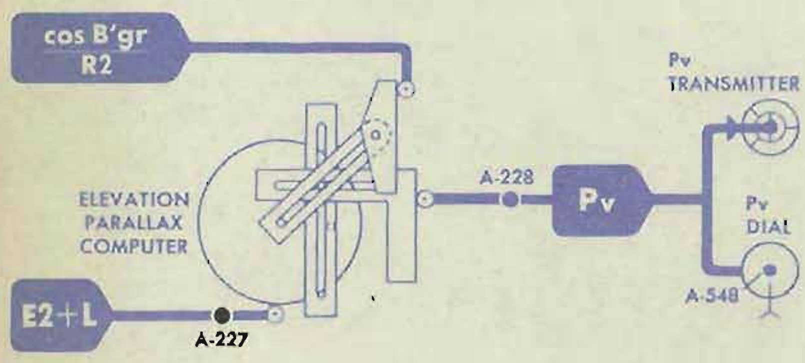
Remove the wedges.

Check A-228.



A-227 Pv COMPUTER to E2 + L LINE





Location

A-227 is under cover 7, below the *Pv* computer. It can be seen by looking down at an angle past the lower end of the coarse *E'g* indicating transmitter.

A-227 is omitted on Mods 0-4, 6, 9, and 10.

Check

Set *E2* at 0°.

Set *L* at 2000'.

The sin (*E2* + *L*) cam should be at its zero position, where any movement of the (cos *B'gr*)/*R2* input rack causes no motion of the *Pv* dial.

Wedge *B'gr* and *Dd* at 0°, and decrease *R2* from 18,000 to 500 yards. The *Pv* dial should not move.

Adjustment

If the *Pv* dial moves, make A-227 slip-tight.

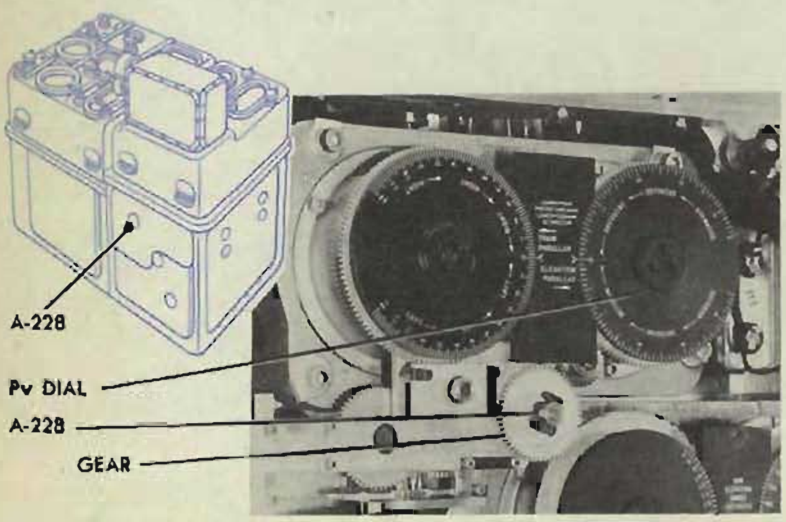
Position the sin (*E2* + *L*) cam until there is no motion of the *Pv* dial for full travel of the (cos *B'gr*)/*R2* rack. The sin (*E2* + *L*) cam is one inch to the right of A-227 and may be moved with a gear pusher.

Tighten A-227, and recheck.

Remove the wedges.

Check A-228.

A-228 Pv DIAL to Pv COMPUTER



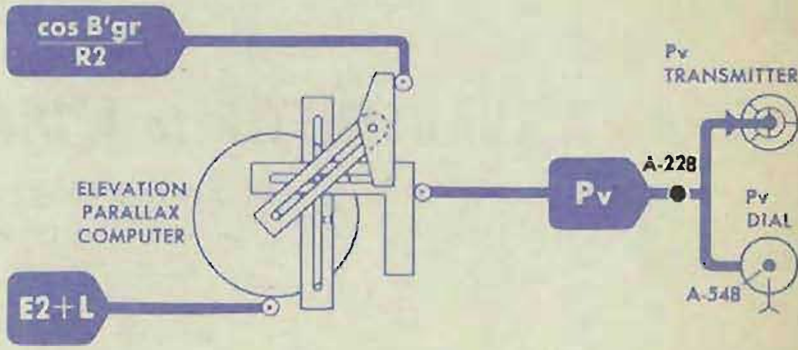
Location

A-228 is under cover 6, below the end of the mask for the *Ph* and *Pv* dials.

A-228 is omitted on Mods 0-4, 6, 9, and 10.

Check

Turn the power OFF.
Set *E2* at 0°.
Set *L* at 2000′.
Set *Dd* at 0° and wedge the line.
Set *B′gr* at 90° and wedge the line.
The *Pv* dial should read 0°.



Adjustment

If the *Pv* dial does not read 0°, make A-228 slip-tight.

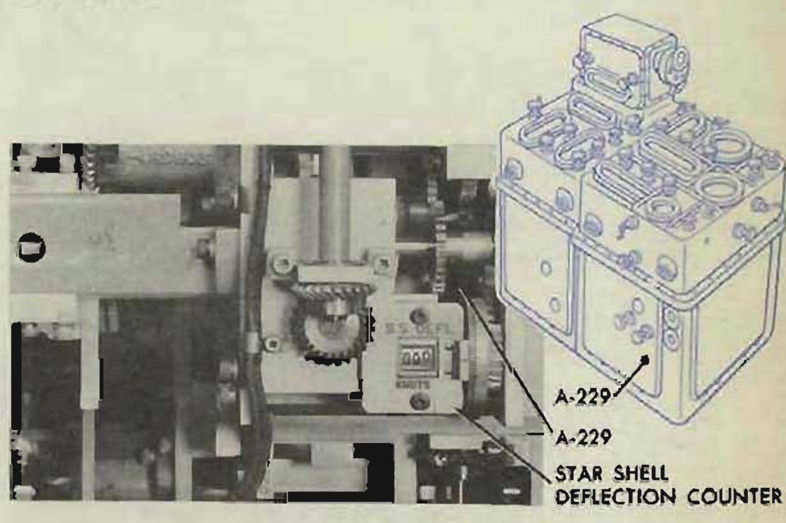
Slipping through A-228, turn the gear next to the clamp until the *Pv* dial is at 0°.

Tighten A-228, and recheck.
Remove the wedges.
Check A-548.

A-229 STAR SHELL DEFLECTION COUNTER to WrD + KRdBs LINE

Location

A-229 is under cover 3.
A-229 is omitted on Mods 0, 1, 2, 3, 9, and 10.

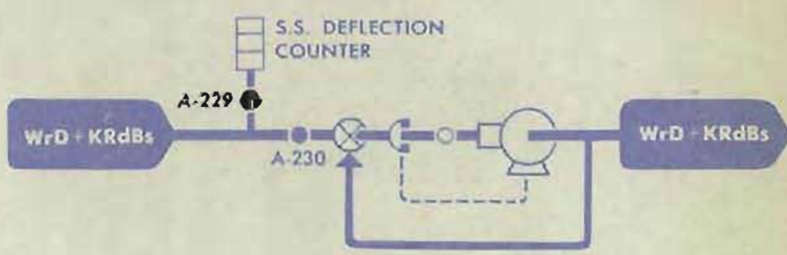


Check

Turn the power ON.
Set *Sh*, *So*, and *Sw* at 0 knots.
Set *A*, *Br*, and *Bws* at 0°.
Set *Ds* at 500 mils.
The star shell deflection counter should read 0 knots.

Adjustment

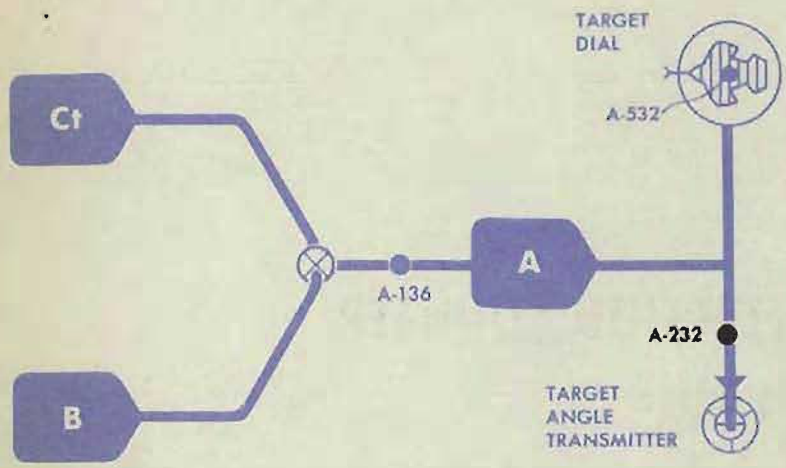
If the counter does not read 0 knots, loosen A-229. Bring the counter to 0 by turning the small spur gear which meshes with the gear on the drum of the counter.



Tighten A-229 and recheck.
Check A-230.

A-230 and A-231 STAR SHELL COMPUTER ADJUSTMENTS

A-232 A TRANSMITTER to A DIAL



Location

A-232 is under cover 1, mounted on a worm, to the rear of the *A* transmitter.

A-232 is omitted on Mods 0, 1, 2, and 9. It is also omitted on all instruments with Ser. Nos. 421 and higher. In other instruments, Ser. Nos. 420 and lower, the *A* transmitter was altered to the *Ct* transmitter, and A-232 became an assembly clamp.

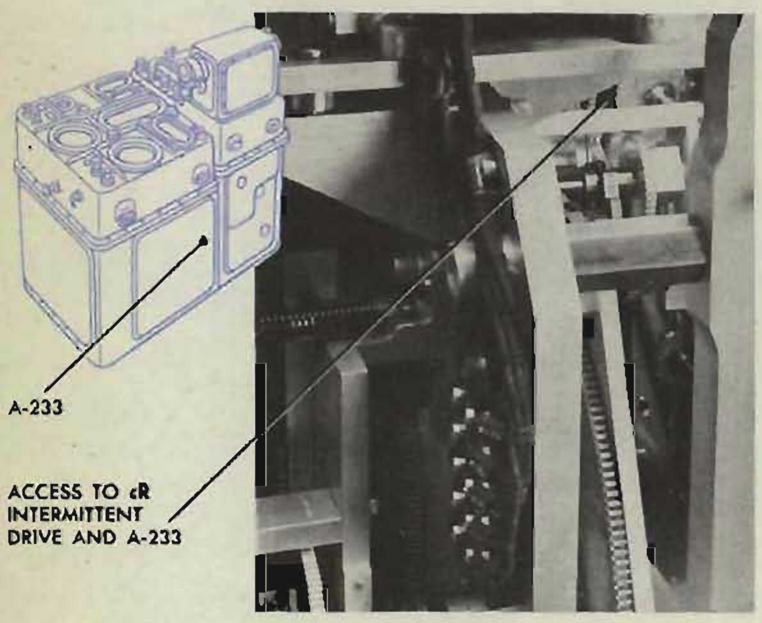
Check

A-232 should be tight. The worm on which it is mounted should be out of mesh.

Adjustment

Tighten A-232 when the worm is out of mesh.

A-233 cR INTERMITTENT DRIVE to cR DIALS



Location

A-233 is under cover 5, to the rear of the integrator mounting plate.

A-233 is omitted on Mods 0, 1, 2, and 9.

Check

Decrease *cR*.
Observe the output gear of the intermittent drive. It should stop turning when the *cR* dials read 750 yards. The intermittent drive is then at its lower cut-out point.

Adjustment

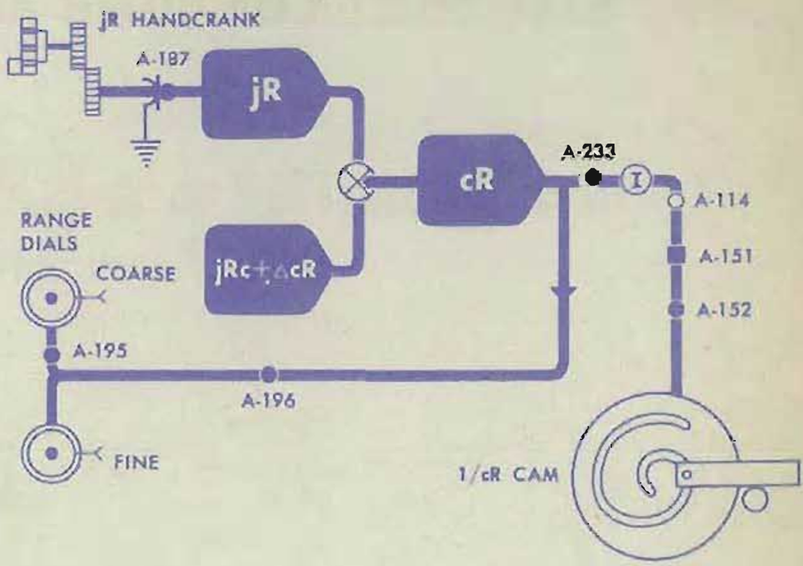
If the intermittent drive output gear does not stop turning when *cR* is decreased to 750 yards, make A-233 slip-tight.

Turn *cR* in a decreasing direction to the exact point where the intermittent drive cuts out.

Hold the large gear in the intermittent drive with a gear pusher. Bring *cR* to 750 yards with the *jR* handcrank.

Tighten A-233.

Increase *cR* until the intermittent drive output gear stops turning. This is the upper cut-out point. The *cR* dials should read 22,500 yards. Recheck at the lower cut-out point. Check A-114 and A-151.

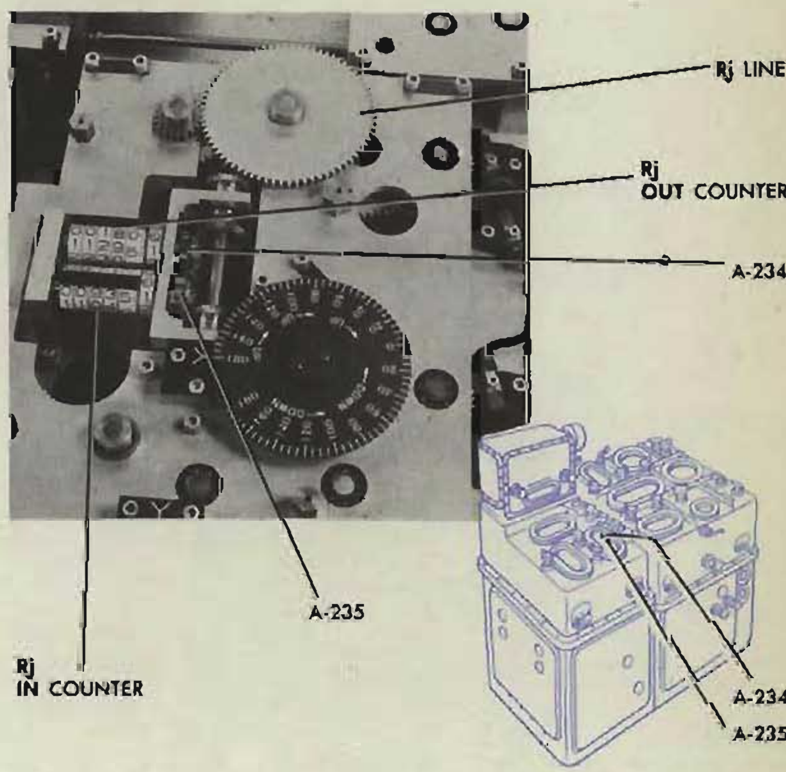


A-234 and A-235 Rj COUNTERS to L-29

A-234 and A-235 are omitted in Mods 0, 1, 2, 5, 6, "Old" Mod 7, and Mod 9. In these mods, see A-502.

Location

A-234 and A-235 are under cover 2, below the dial mask for the *Rj* counters. They are on the ends of the *Rj* counter shafts.
A-234 is on the *Rj* OUT counter.
A-235 is on the *Rj* IN counter.
L-29 is under cover 5, in a horizontal position, with its lower limit toward the front.



Check

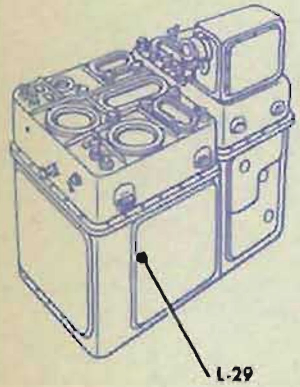
L-29 should reach the lower limit when the *Rj* IN counter reads 12,000 yards, and the upper limit when the *Rj* OUT counter reads 1800 yards.

A-235 Check

Run *Rj* to its IN limit. The *Rj* IN counter should read 12,000 yards.

A-235 Adjustment

If the *Rj* IN counter does not read 12,000 yards, make A-235 slip-tight. Set the counter at 12,000 yards. Tighten A-235.



A-234 Check

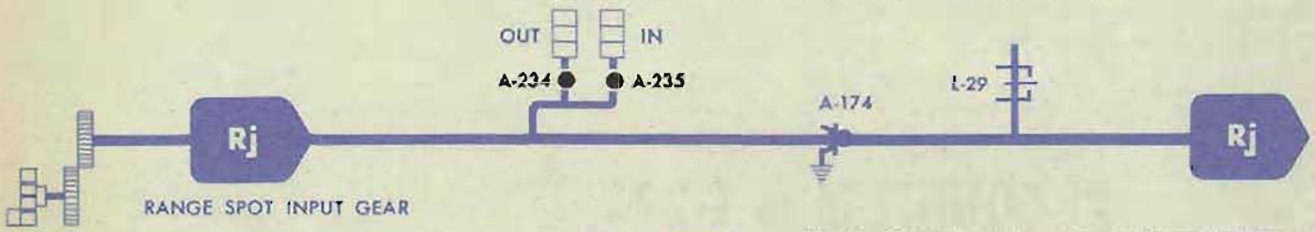
Run *Rj* to the OUT limit. The *Rj* OUT counter should read 1800 yards.

A-234 Adjustment

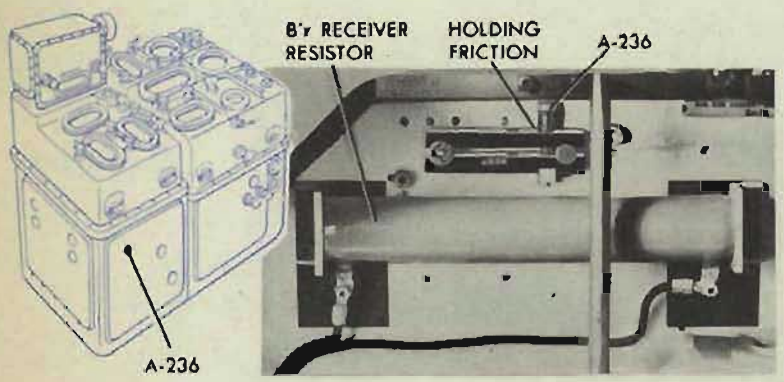
If the *Rj* OUT counter does not read 1800 yards, make A-234 slip-tight. Set the counter at 1800 yards. Tighten A-234.

Recheck

Again run L-29 to its limits. The *Rj* IN counter should read 12,000 yards at the lower limit and the *Rj* OUT counter should read 1800 yards at the upper limit. Split any overtravel and check that the counters read zero simultaneously.



A-236 Dd HOLDING FRICTION



Location

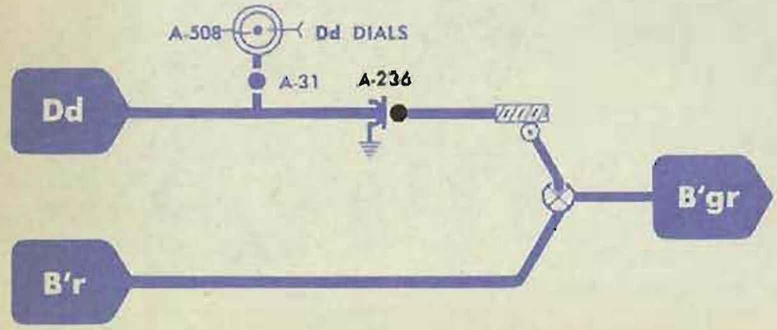
A-236 is under cover 8, above the *B'r* receiver resistor.
A-236 is not in Mod 0.

Check

This friction should be tight enough to prevent *B'r* from backing out *Dd* when the *B'r* receiver is driving *B'gr*. It should not be so tight as to overload the *Dd* servo motor.

Adjustment

Tighten the screw all the way down; then back off two turns. Refine the adjustment by tightening or loosening the screw just enough to prevent *B'r* from backing out and yet allow the *Dd* motor to drive freely.



CAUTION

Do not tighten the screw so much that the spring is compressed solidly, as this overloads the *Dd* servo motor.

A-238 ASSEMBLY CLAMP

Location

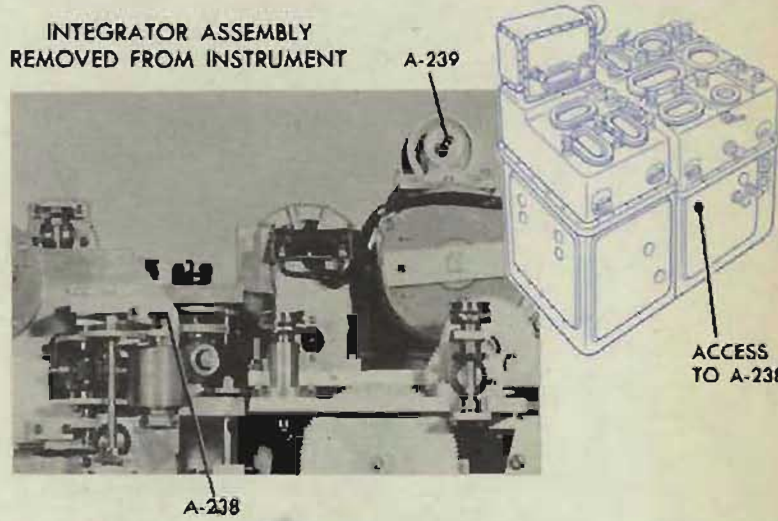
A-238 is under cover 5, on the upper end of the magnetic drag of the bearing filter.
A-238 is omitted on Mod 0.

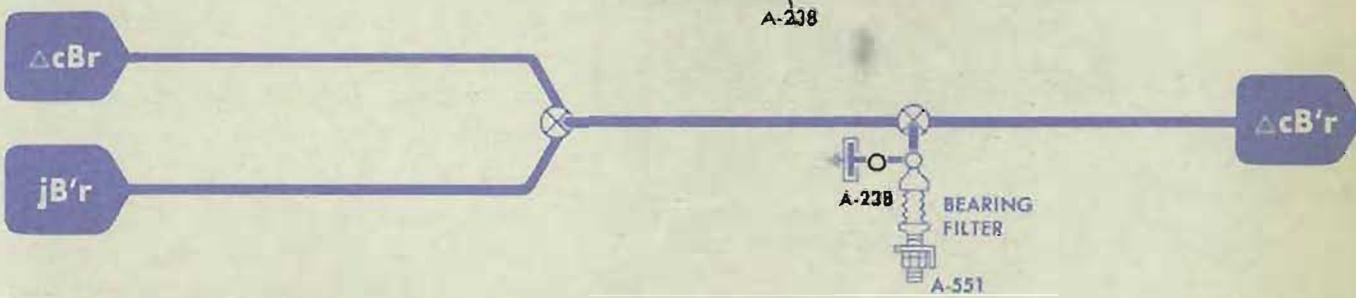
Check

A-238 should be tight, with the gear on which it is mounted in mesh with the sector gear of the bearing filter.

Adjustment

Tighten A-238.





A-239 ASSEMBLY CLAMP

Location

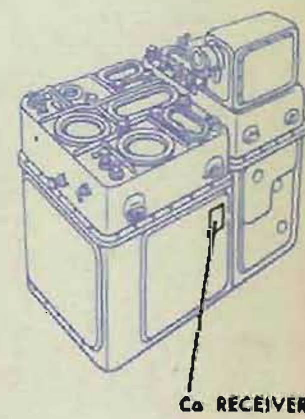
A-239 is under cover 5, on the front end of the magnetic drag on the *Co* receiver.
A-239 is omitted on Mod 0.

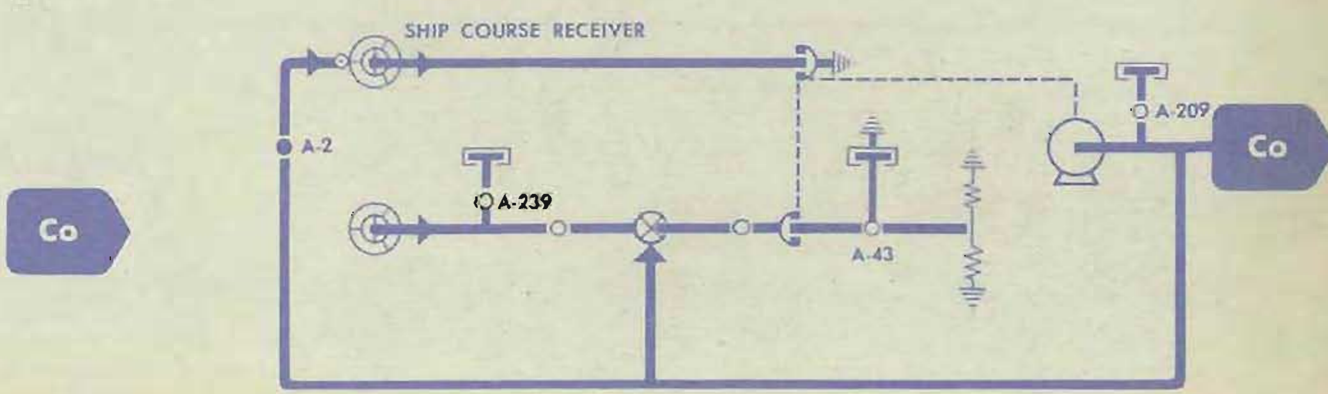
Check

A-239 should be tight, with the gear on which it is mounted in mesh with its mating gear.

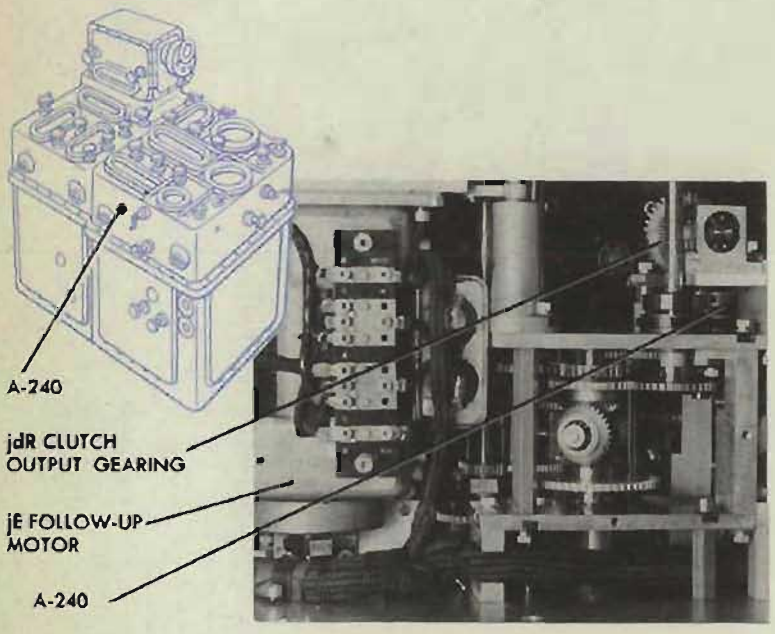
Adjustment

Tighten A-239.





A-240 jdR HOLDING FRICTION



Location

A-240 is under cover 1, at the rear of the elevation component integrator. A-240 is omitted on instruments with Ser. Nos. 100 and lower.

Check

This friction should be tight enough to prevent *E* or *jEc* from backing out *jdR*, but not so tight as to overload the *jdR* motor during automatic range rate control.

Turn *E* and observe the *jdR* clutch output gearing. It should remain motionless. Repeat the check, turning *jEc*.

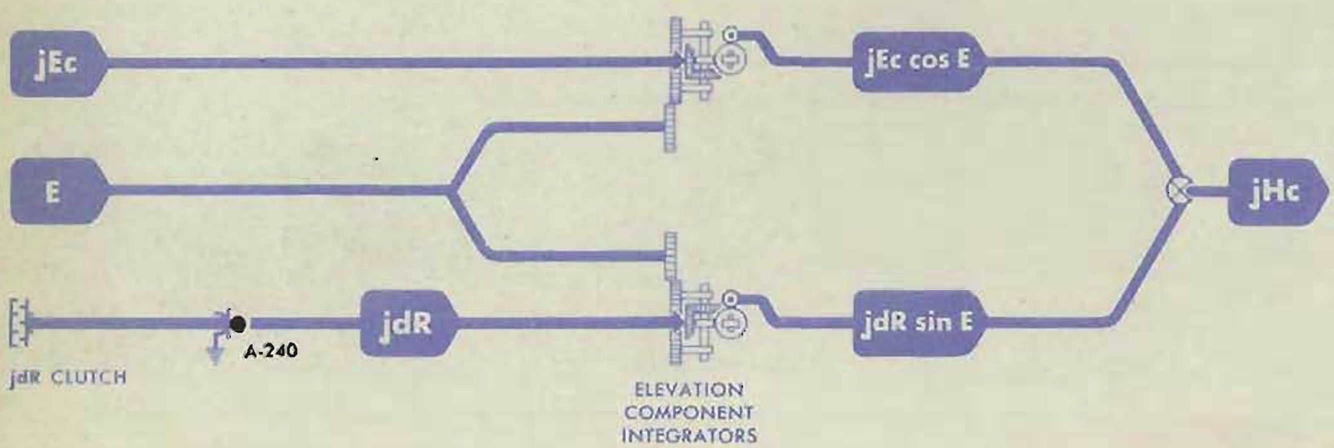
Run the synchronizing test of the range receiver, page 62. Check that the *jdR* motor drives fast enough to synchronize within the prescribed time limit.

Adjustment

If both conditions under the check are not obtained, loosen A-240.
If the *jdR* line backs out, turn the clamp clockwise to increase the friction.
If the *jdR* motor drives too slowly, turn the clamp counterclockwise to decrease the friction.

Tighten A-240 and recheck.

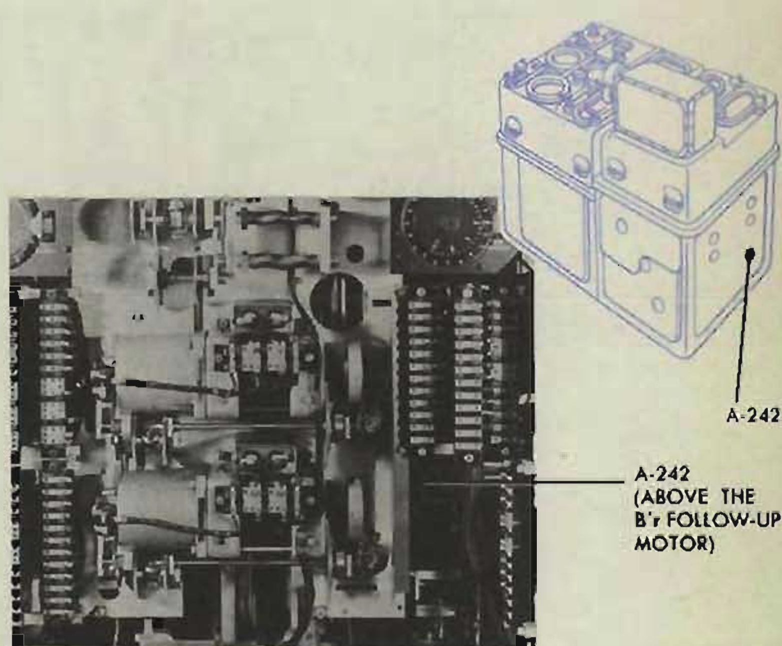
Check A-164.



A-242 B'r or B'gr SLIDE GEAR to PARALLAX SECTION

Location

A-242 is located under cover 7. It consists of a flat clamp on a double slide gear. A-242 is omitted on instruments with Ser. Nos. 215 and lower.



Check

Gun train order drives the vector gear of the parallax component solver on CV's and all one-director ships. On these ships the slide gear should be pushed *up* into mesh with the *B'gr* line.

Director train drives the vector gear of the parallax component solver on BB's, CA's, CB's, CL's, and CVB's. On these ships the slide gear should be pushed *down* into mesh with the *B'r* line.

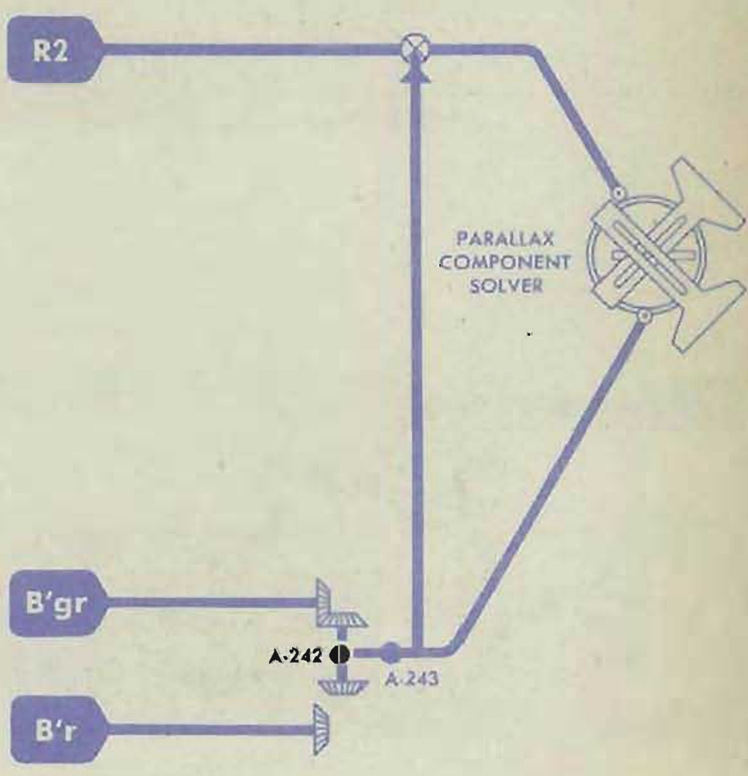
Adjustment

If the slide gear is not adjusted properly, set *B'r* equal to *B'gr*. Loosen the two screws and move the slide gear into mesh with the gear on the proper line.

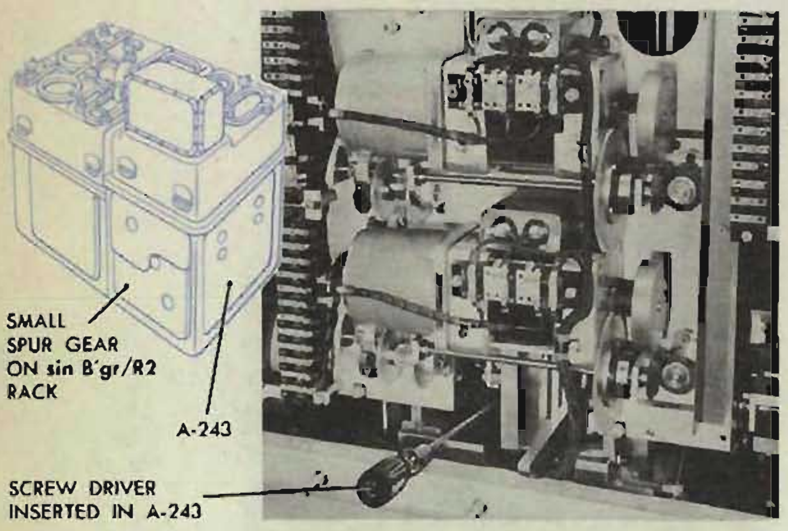
Tighten A-242.

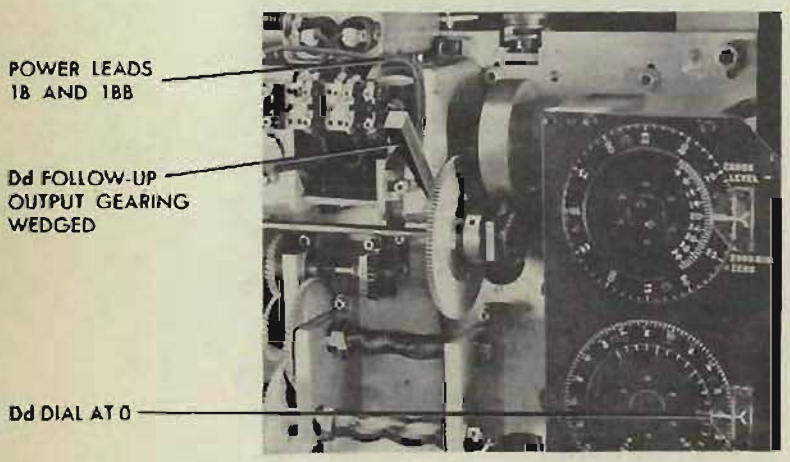
Check to make sure that the gear mesh is not too tight and that there is no excessive lost motion.

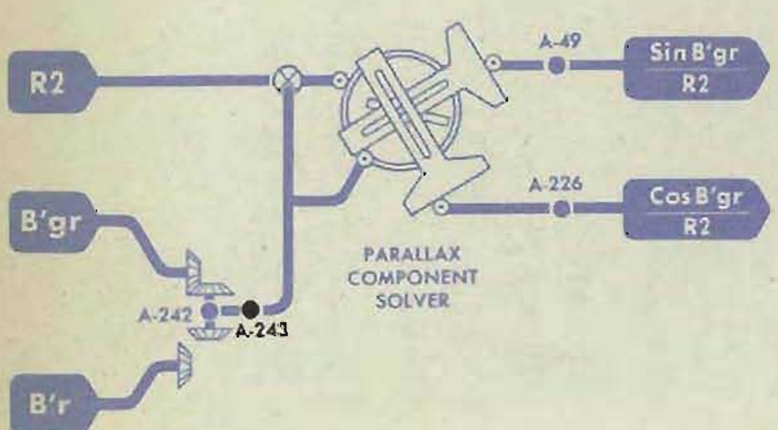
Check A-243.



A-243 PARALLAX COMPONENT SOLVER to B'r or B'gr LINE







Location

A-243 is under cover 7, about 18 inches in from an opening below the center of the *Vz* follow-up.
A-243 is omitted on instruments with Ser. Nos. 215 and lower. Use A-68 to make this adjustment.

Rough check

Regardless of whether the *B'gr* or *B'r* line is meshed to the parallax component solver, this method is used.

Set *Dd* at 0°.
Remove leads 1B and 1BB from the *Dd* follow-up and wedge the output gearing.

Turn the power ON.

At the switchboard, turn off the *B'r* receiver switch.

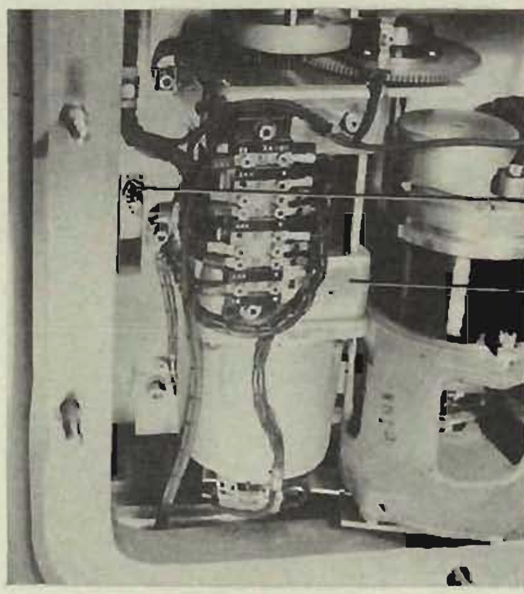
Set the *B'gr* dials at 90° and wedge the line. Decrease *R2*. Use the generated range crank.

The vector gear slot of the parallax component solver should be at the position where the *Ph* dials turn clockwise when *R2* is decreased. The *Ph* dials turn clockwise when *Ph* is increasing.

Fine check

Set *B'gr* at 0°.

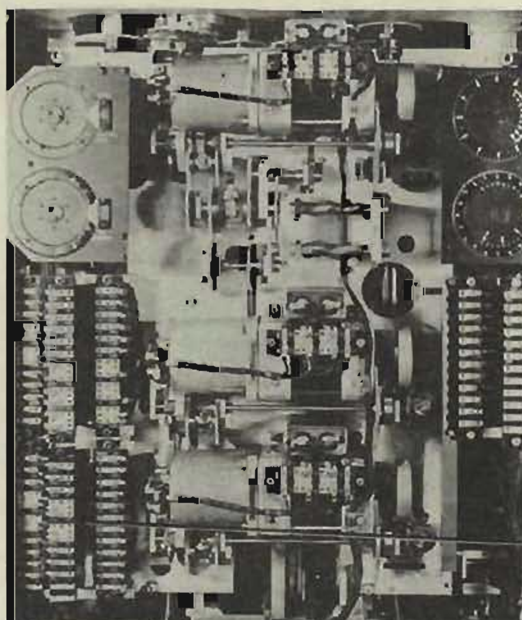
With $B'gr$ and Dd at 0°, changing $R2$ should not move the (sin $B'gr$)/$R2$ output rack of the parallax component solver.



Set $R2$ at 18,000 yards and then decrease it to 1500 yards. Motion of the (sin $B'gr$)/$R2$ rack can be observed on the small spur gear on which A-49 is mounted, under cover 6. This gear is 6 inches in, at the left side of the *Eb* receiver terminal block.

Adjustment

If there is any movement of the (sin $B'gr$)/$R2$ rack during the fine check, make A-243 slip-tight.
Set $R2$ at 18,000 yards and mark the small spur gear next to A-49. Decrease $R2$ to 1500 yards.
Turn the $B'gr$ line to return the spur gear to the original mark.

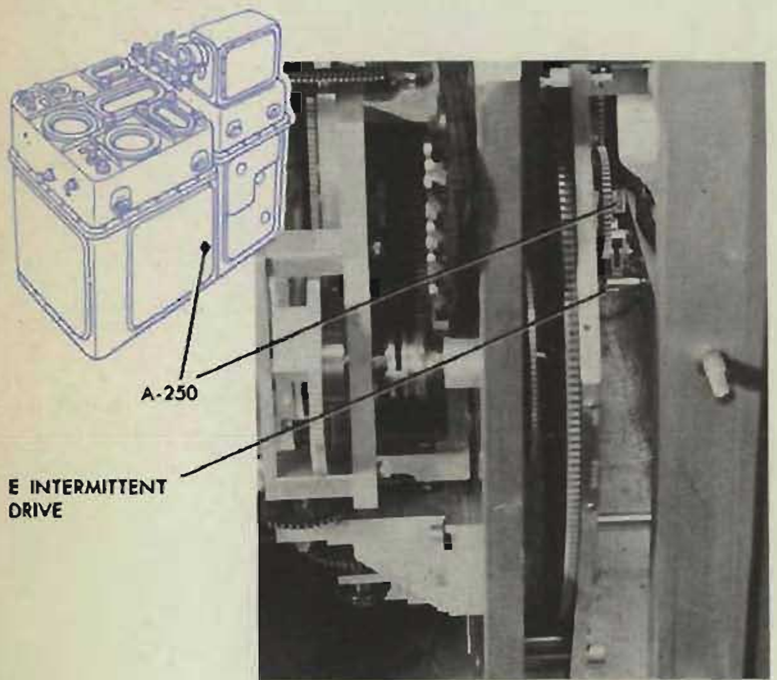


Then hold the vector gear in position, and turn the $B'gr$ line to bring the $B'gr$ dials to zero, slipping at A-243.
The vector gear may be held in position by holding the large bevel gear 12 inches in from the lower right terminal block. This gear is in line with terminal 163 and the inner end of the coarse $E'g$ indicating transmitter.

Tighten A-243, and recheck.

Replace leads 1B and 1BB on the *Dd* follow-up. Check A-226 and A-49.

A-250 E INTERMITTENT DRIVE to E DIALS



Location

A-250 is under cover 5, to the rear of the large integrator mounting plate. It is on the spur gear input of the *E* intermittent drive.

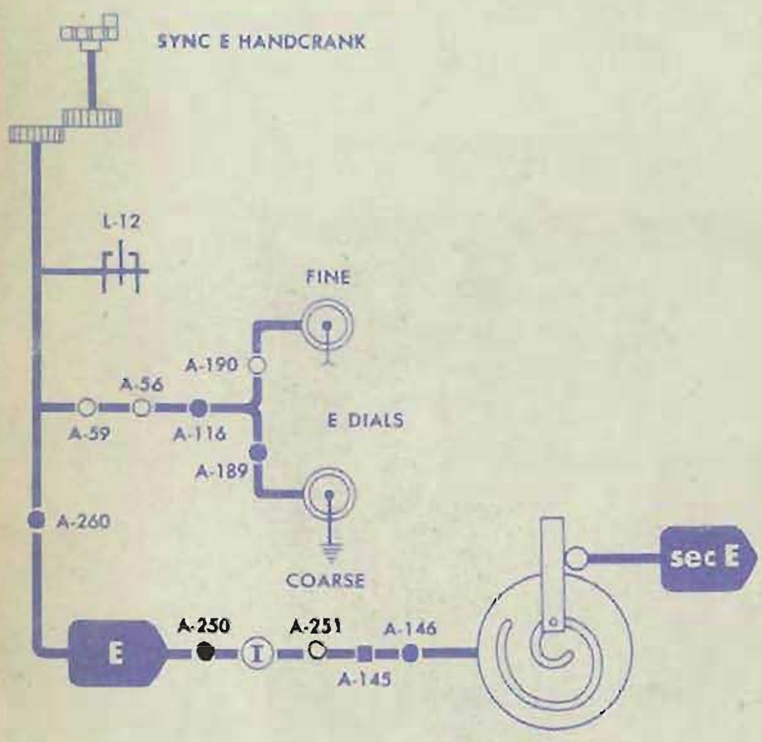
A-250 is on instruments with Ser. Nos. 390 and higher, only.

Check

Decrease *E*. The output gear of the intermittent drive should stop turning when the *E* dials read $-2°$. The intermittent drive is then at its lower cut-out point.

CAUTION

If *E* cannot be decreased to $-2°$, A-146 or A-147 is upset and the end of travel has been reached on the sec *E* cam or the sec *E* integrator. If any restriction can be felt, loosen A-146.



Adjustment

If the intermittent drive output gear does not stop turning at $-2°$, make A-250 slip-tight.

Turn *E* in a decreasing direction until the point is reached where the intermittent drive output gear just stops turning. Use a gear pusher to hold the large gear in the intermittent drive. Bring the *E* dials to $-2°$ with the sync *E* handcrank.

Tighten A-250 and recheck.
Increase *E* until the output gear stops turning. The *E* dials should read $+85°$. This is the upper cut-out point of the intermittent drive.
Check A-251.

Readjust A-146, A-145, and A-147.

A-251 ASSEMBLY CLAMP

See A-114.

A-254 ASSEMBLY CLAMP (Mods 8 and 12)

Location

A-254 is under cover 7, on the input to the *R2* intermittent drive, behind the *E'g* indicating transmitters.

Check

Check A-92.
Check A-156 (Mods 8 and 12).
If the intermittent drive cuts out at the wrong point, but A-92 is correctly adjusted, A-254 is in error.

Adjustment

Readjust A-254 in accordance with the procedure for adjusting A-156 on Mods 8 and 12.

Check A-255 and A-256.

A-255 ASSEMBLY CLAMP (Mods 8 and 12)

See A-114.

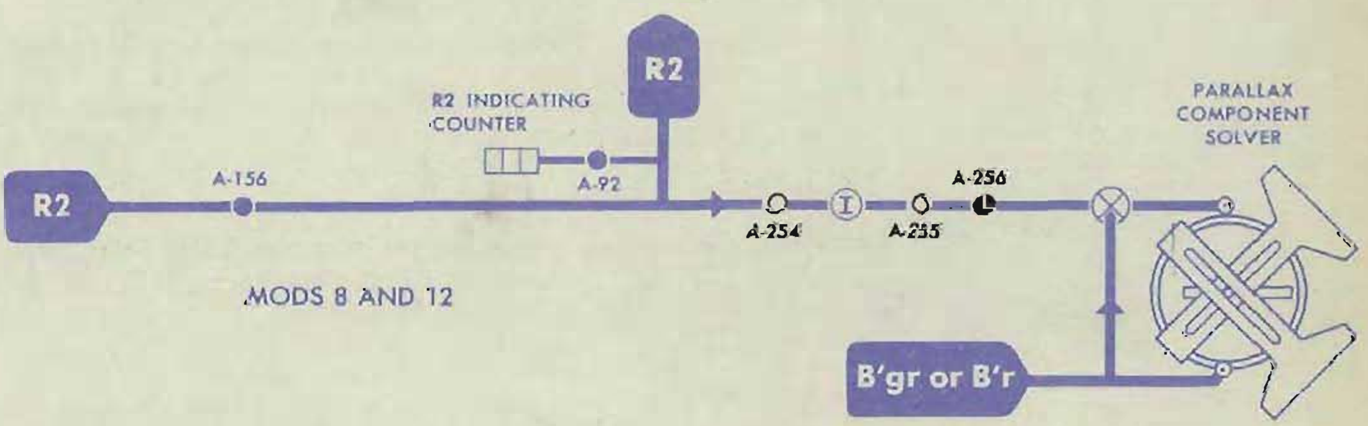
A-256 PARALLAX COMPONENT SOLVER to R2 COUNTER (Mods 8 and 12)

Location

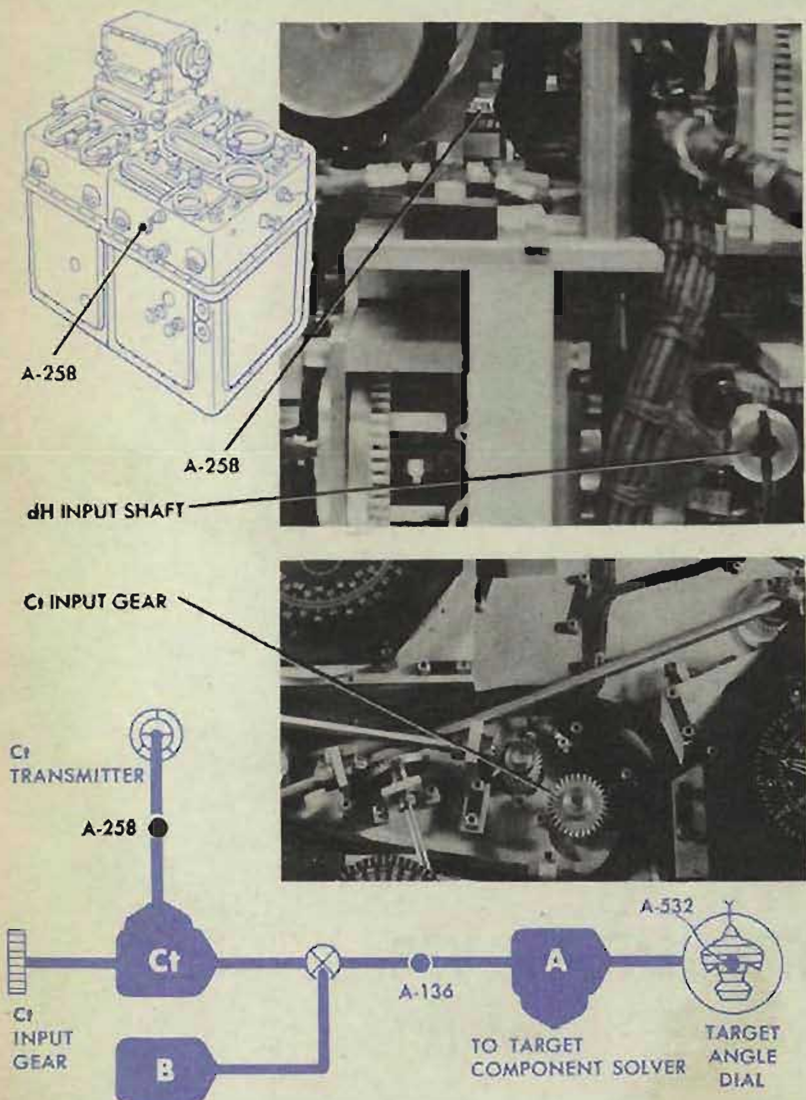
A-256 is under cover 7 on the output of the *R2* intermittent drive.

Check and adjustment

Refer to the check and adjustment of A-156 on other mods.



A-258 Ct TRANSMITTER to A DIAL



Location

A-258 is under cover 1, to the front of the *Ct* transmitter.

Note

The *Ct* transmitter was formerly the *A* transmitter. Check that A-232 is tight and properly out of mesh on Ser. Nos. 420 and lower except on Mods 0, 1, 2, and 9, where it is omitted. A-258 is also omitted on Mods 0, 1, 2, and 9.

Check

Connect a standard motor (test synchro) to the *Ct* transmitter terminals.
Set *B* at 180°.
Set *A* at 0°.
The rotor of the *Ct* transmitter synchro should be on electrical zero. It is on electrical zero when the standard motor dial index matches the fixed index.

Adjustment

If the rotor of the synchro is not on electrical zero, make A-258 slip-tight. Use the *Ct* input gear to turn the rotor until the synchro is on electrical zero. Secure the rotor by holding the worm about 2 inches above A-258.
Turn the *Ct* input gear to bring *A* back to 0°.
Tighten A-258, and recheck.
Disconnect the standard motor from the *Ct* transmitter.

A-259 E COUNTER IN CORRECTOR UNIT to E DIALS

Location

A-259 is centrally located, where the corrector and computer units join, accessible from cover 8.

Check

The reading on the *E* counter in the corrector unit should agree with the reading on the *E* dials.
NOTE: The *E* counter is installed only in computers with Ser. Nos. 435 and higher.

Adjustment

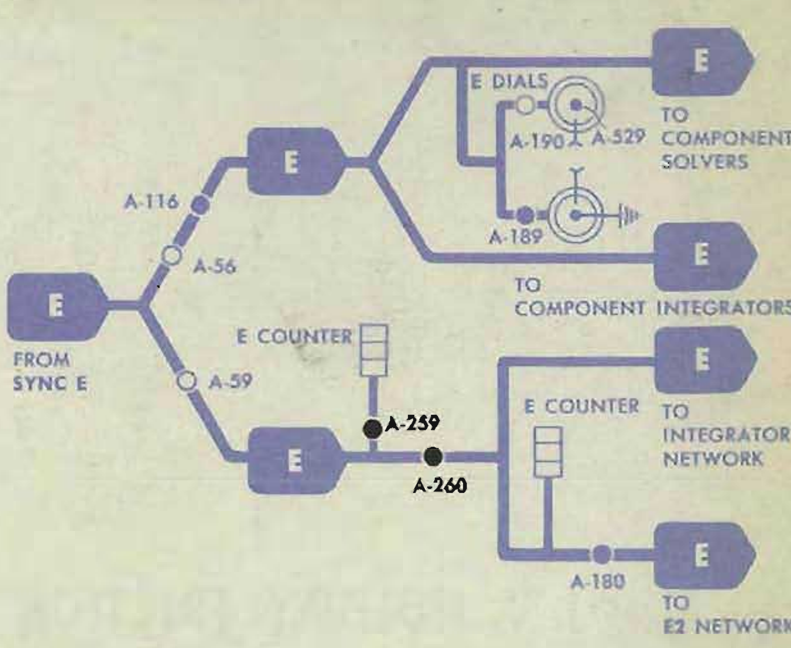
If the counter reading does not agree with the dial reading, slip-tighten A-259. Set the counter to read the same value as the *E* dials.
Tighten A-259.

Check A-260.

A-260 E COUNTER IN COMPUTER UNIT to E DIALS

Location

A-260 is located where the computer and corrector units join, a few inches away from A-259. It is accessible from cover 5.



Check

The reading on the *E* counter in the computer unit should agree with the reading on the *E* dials.

NOTE: The *E* counter is installed only in computers with Ser. Nos. 435 and higher.

Adjustment

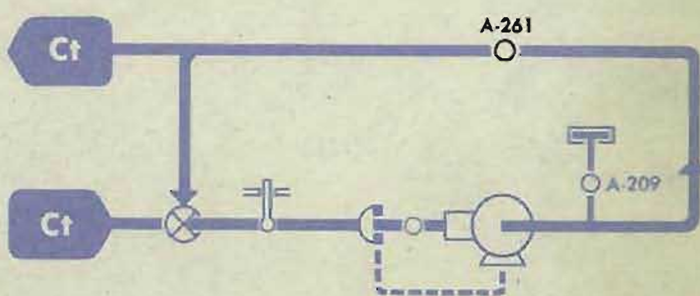
If the *E* counter reading does not agree with the *E* dial reading, slip-tighten A-260. Set the *E* counter to read the same value as the dials. Tighten A-260 and recheck.

NOTE: A-260 and A-259 are usually adjusted at the same time.

A-261 ASSEMBLY CLAMP

Location

A-261 is under cover 1, in the *Ct* follow-up control gearing.



Check

A-261 should be tight.

Adjustment

Tighten A-261.

A-262 Tg + F – Tf LINE to L-14

Location

A-262 is under cover 3, above the *I.V.* dial, on Ser. Nos. 781 and higher.

Fuze at 49

L-14 Lower lim

Tf – 49.08

Check

Mod 15 – F 49 Stops To .6

L-14 - upper at .6

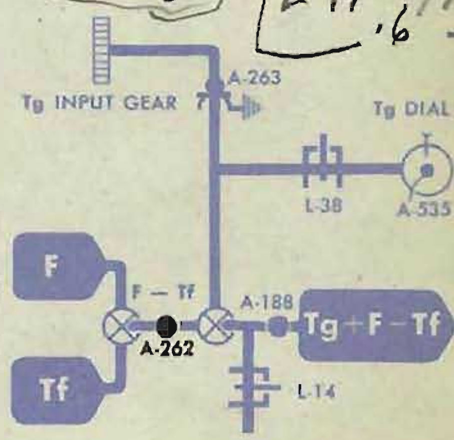
Turn the power OFF.

On Mod 13:

- Set *Tg* at 0 sec.; set *F* at 51 sec.; turn *Tf*.
- L-14 should act when *Tf* reads 1 and 51 sec.

On Mods 8 and 12:

- Set *Tg* at 5 sec.; set *F* at 48 sec.; decrease *Tf*.
- Upper limit of L-14 should act when *Tf* reads 3 sec.
- Set *F* at 45 sec.; increase *Tf*.
- Lower limit of L-14 should act when *Tf* reads 50 sec.

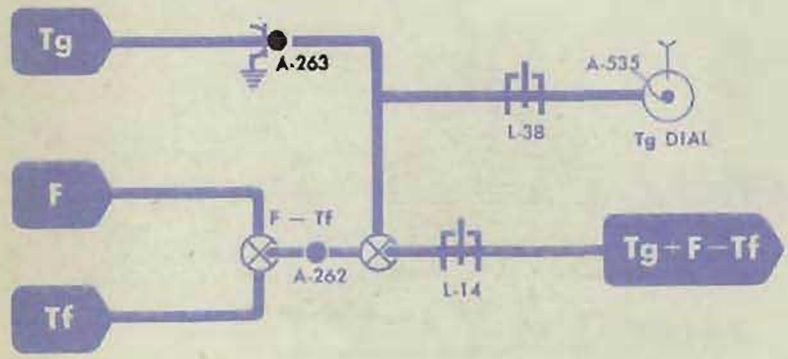


Adjustment

If the limits of L-14 are incorrect, loosen A-262. Hold the *Tg* + *F* – *Tf* line against the limit. Turn the *Tf* line until the counter reads the correct value. Tighten A-262, and check the other limit.

Check A-188.

A-263 Tg HOLDING FRICTION



Location

A-263 is under cover 3, behind the *Tg* input gear on Ser. Nos. 781 and higher.

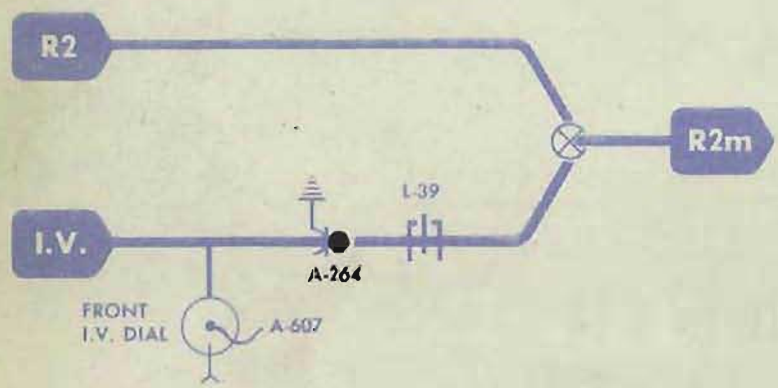
Check

The *Tg* friction load should be heavy enough to hold the *Tg* dial on its setting during operation of the computer.

Adjustment

Loosen the screw in A-263. Turn the clamp clockwise to increase the friction. Tighten the screw.

A-264 I. V. HOLDING FRICTION



Location

A-264 is under cover 4, in the *Tf/R2* ballistic computer gearing, to the right of the *I.V.* dial, on Ser. Nos. 811 and higher.

Check

The friction should be tight enough to hold the *I.V.* setting.

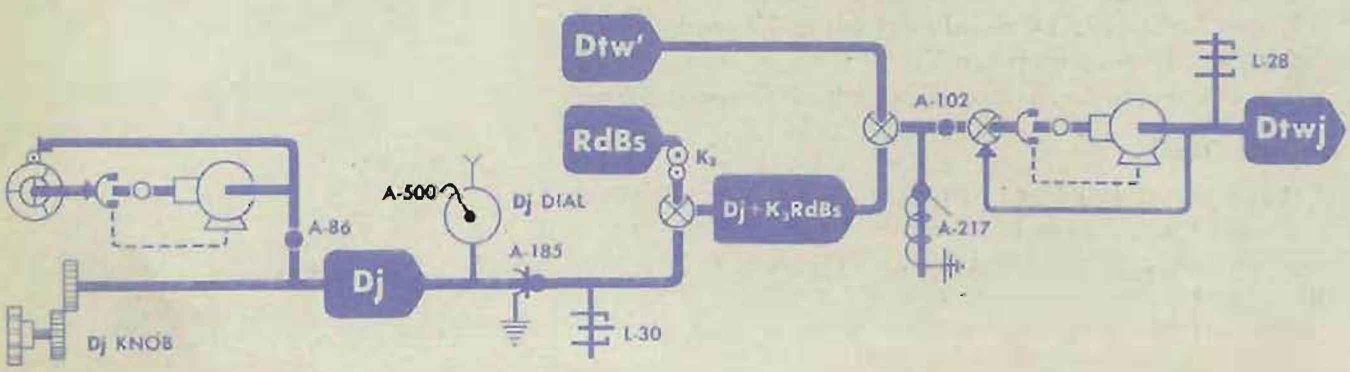
Adjustment

Loosen the screw in A-264. Turn the clamp clockwise to increase the friction.
Tighten the screw.

A-500 Dj DIAL to L-30

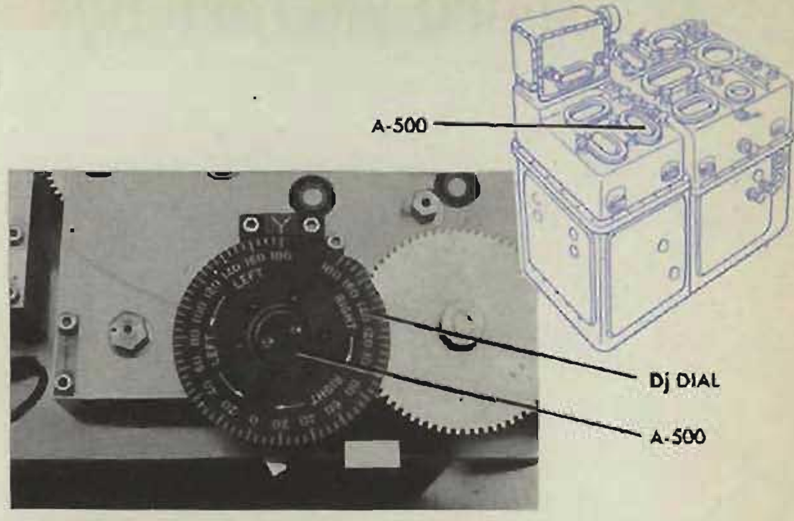
Location

A-500 is under cover 2, on the *Dj* dial.



Check

Decrease *Dj* until the lower limit of L-30 is reached. The *Dj* dial should read LEFT 180 mils.



Adjustment

If the *Dj* dial does not read LEFT 180, loosen A-500. Hold the line against the stop, and slip the dial to the correct reading. Tighten A-500 and check at the upper limit. The *Dj* dial should read RIGHT 180.

Readjust A-86. Check A-102.

A-501 Vj DIAL to L-31

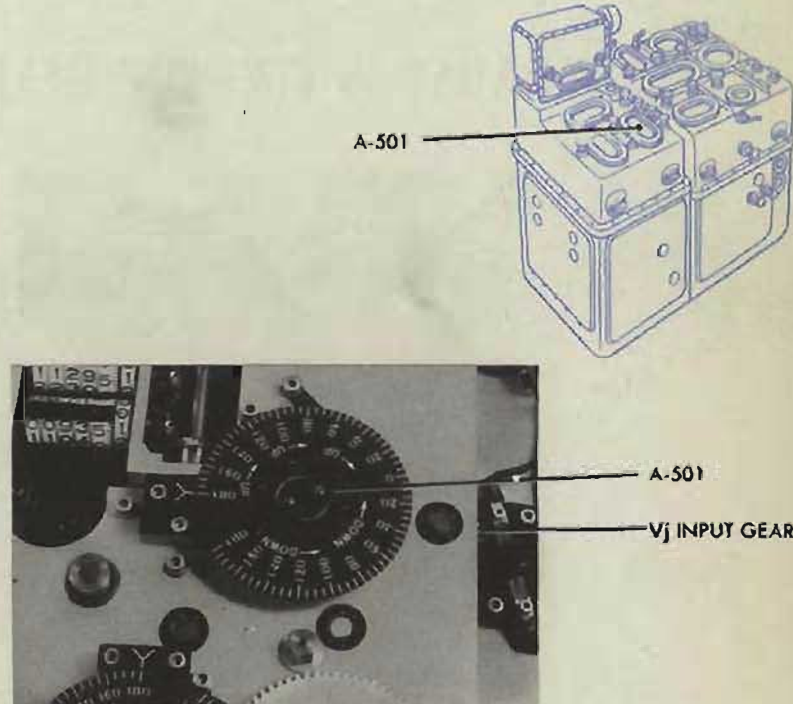
Location

A-501 is under cover 2 on the *Vj* dial.

Check

Turn the power OFF.
Turn the *Vj* input gear to increase *Vj* until the upper limit of L-31 is reached.
The dial should read UP 180 mils.

On Mods 8 and 12, the upper limit is 342.5 mils (24,600 yards on the overlaid transparent dial).



Adjustment

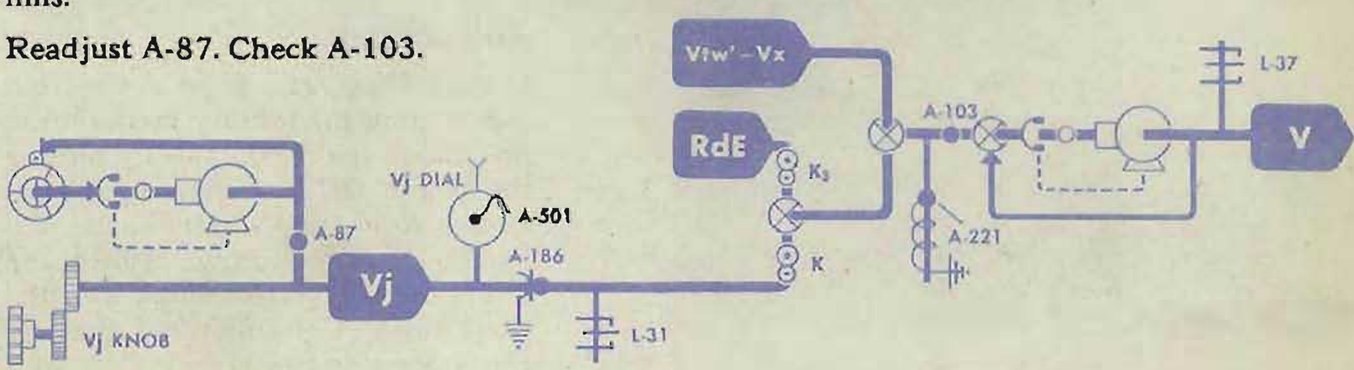
If the *Vj* dial does not read the proper value, loosen A-501. Hold the *Vj* line against the stop, and slip the dial to the correct reading.

Tighten A-501.

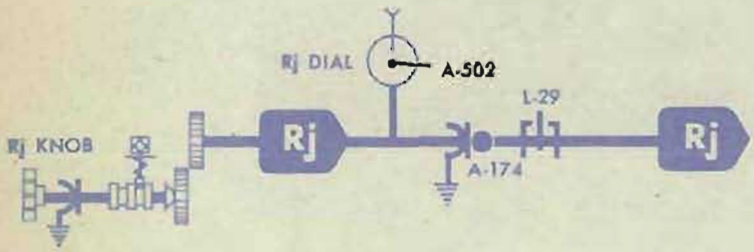
Recheck

Run the *Vj* line to the lower limit. The *Vj* dial should read DOWN 180 mils.

Readjust A-87. Check A-103.



A-502 Rj DIAL to L-29



Location

A-502 is under cover 2 on the *Rj* dial, on Mods 0, 1, 2, 5, 6, "Old" 7, and 9, only.

Check

Turn *Rj* to the upper limit of L-29. The *Rj* dial should read 1800 yards OUT.

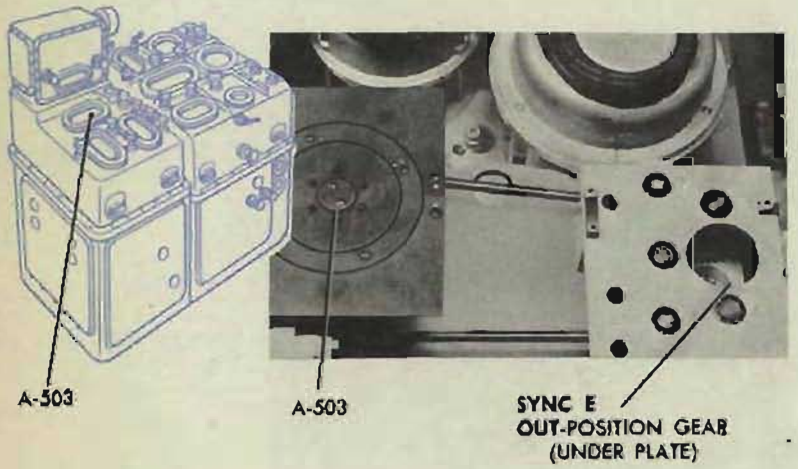
Turn *Rj* to the lower limit. The *Rj* dial should read 1800 yards IN.

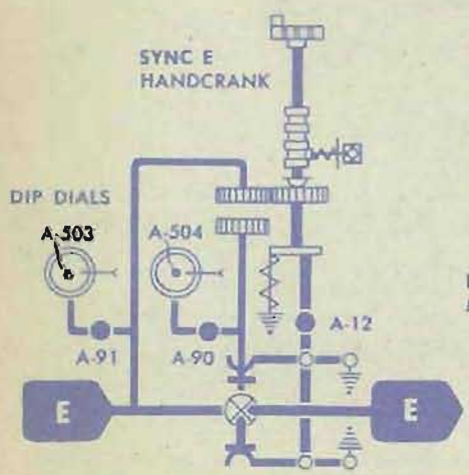
Adjustment

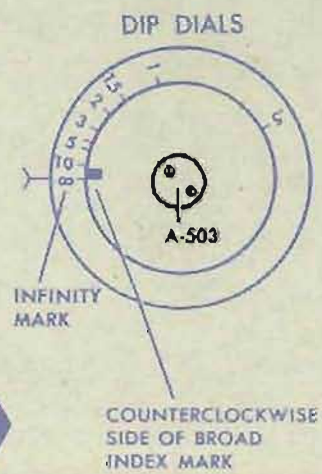
Loosen A-502.
Hold the *Rj* line against the limit stop.
Slip the dial to the proper reading.
Tighten A-502, and check at the other limit.

Check A-104 and A-88.

A-503 COARSE to FINE DIP DIAL







Location

A-503 is under cover 2, on the coarse dip dial.

Check

Set the counterclockwise side of the broad index mark on the coarse dial against the fixed index. The infinity mark of the fine dial should also be at the fixed index.

Set the clockwise side of the broad index on the coarse dial against the fixed index. The ring dial should read 0.5.

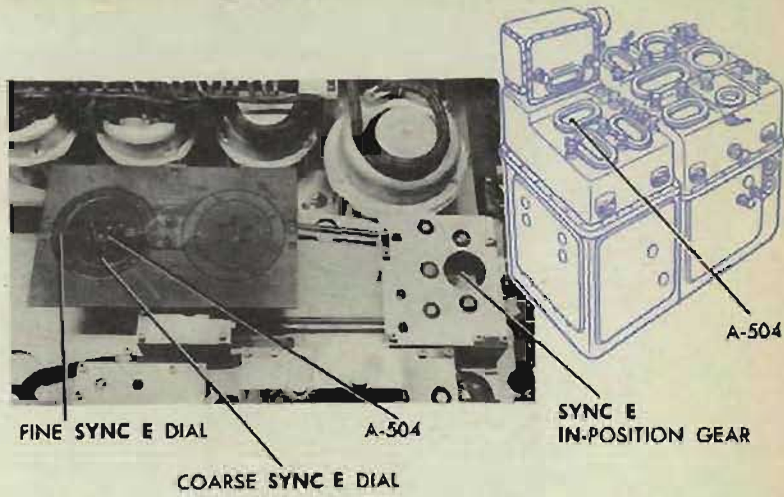
Adjustment

If the dials do not agree at the fixed index, bring the infinity mark on the fine dial to the fixed index by turning the sync *E* OUT-position input gear. Loosen A-503 and slip the coarse dial until the counterclockwise side of the broad index mark is in line with the fixed index. Tighten A-503, and recheck. Readjust A-91.

A-504 COARSE to FINE SYNC E DIAL

Location

A-504 is under cover 2, on the hub of the coarse sync *E* dial.



Check

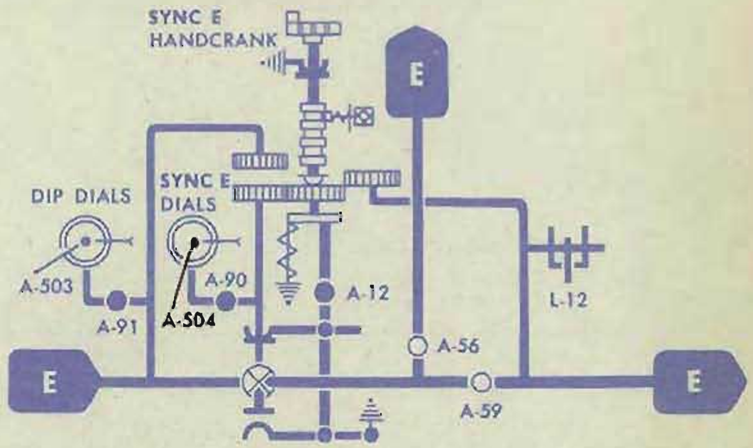
Set the index on the coarse dial at the fixed index. The index on the fine dial should also be at the fixed index.

Adjustment

If both dials cannot be set at the fixed index, bring the index on the fine dial to the fixed index by turning the sync *E* IN-position input gear.

Loosen A-504 and slip the coarse dial until the coarse index matches the fixed index and the fine dial graduation.

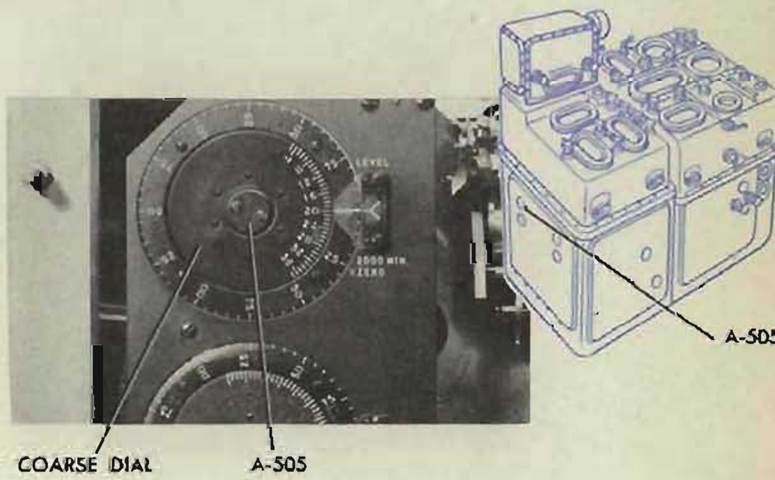
Tighten A-504, and recheck.
Check A-90.



A-505 COARSE to FINE L DIAL

Location

A-505 is under cover 7, on the coarse *L* dial.



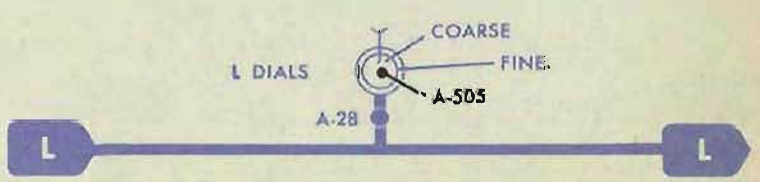
Check

Turn the *L* line at the stable element to set the computer *L* dials at 2000′. When the coarse dial reads 20, the fine dial should read 00.

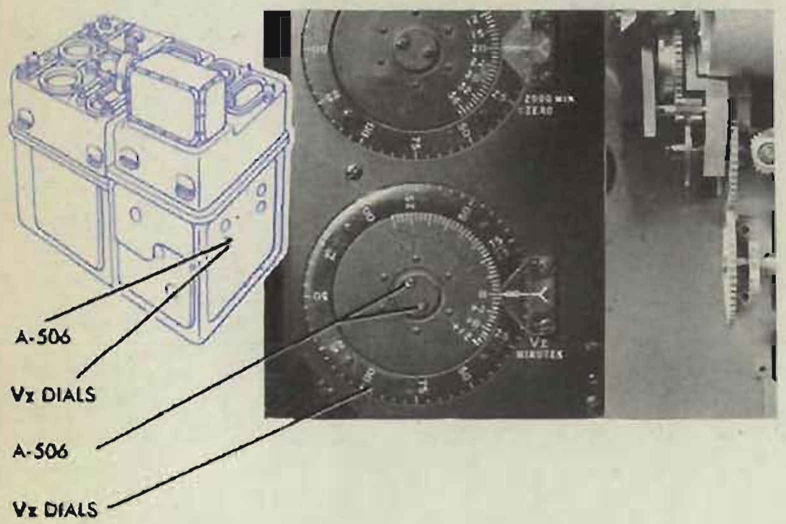
Adjustment

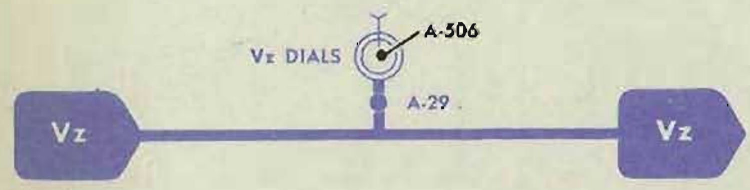
If the coarse dial does not read 20 when 00 on the fine dial matches the index, loosen A-505 and slip the coarse dial to 20.

Tighten A-505 and recheck.
Check A-28.



A-506 COARSE to FINE Vz DIAL





Location

A-506 is under cover 7, on the coarse *Vz* dial.

Check

Turn the power OFF.

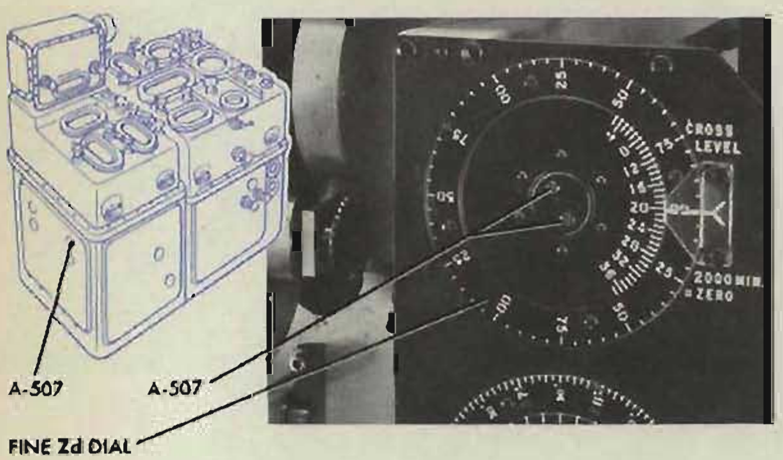
Set the 0 graduation on the coarse *Vz* dial at the fixed index by turning the output gearing on the *Vz* follow-up. The 00 graduation on the ring dial should be in line with the 0 graduation on the coarse dial and the fixed index.

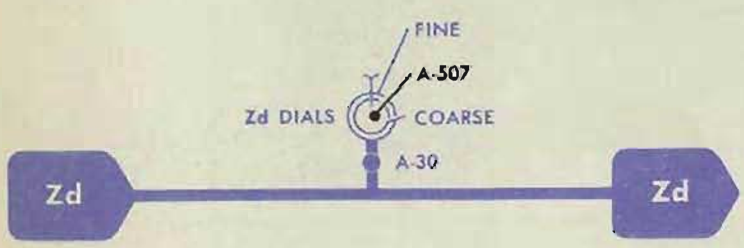
Adjustment

If the dial readings do not agree, bring the 00 reading on the fine *Vz* dial to the fixed index. Loosen A-506 and slip the 0 mark on the coarse *Vz* dial to the fixed index.

Tighten A-506, and recheck.
Check A-29.

A-507 COARSE to FINE Zd DIAL





Location

A-507 is under cover 7, on the coarse *Zd* dial.

Check

Set the computer *Zd* dials at 2000′ by turning the *Zd* shaft line. When the fine dial is at 00, the coarse dial should read 20.

Adjustment

If the coarse *Zd* dial does not read 20, loosen A-507, and slip the coarse dial to 20.

Tighten A-507, and recheck.
Check A-30.

A-508 COARSE to FINE Dd DIAL

Location

A-508 is under cover 7, on the coarse *Dd* dial.

Check

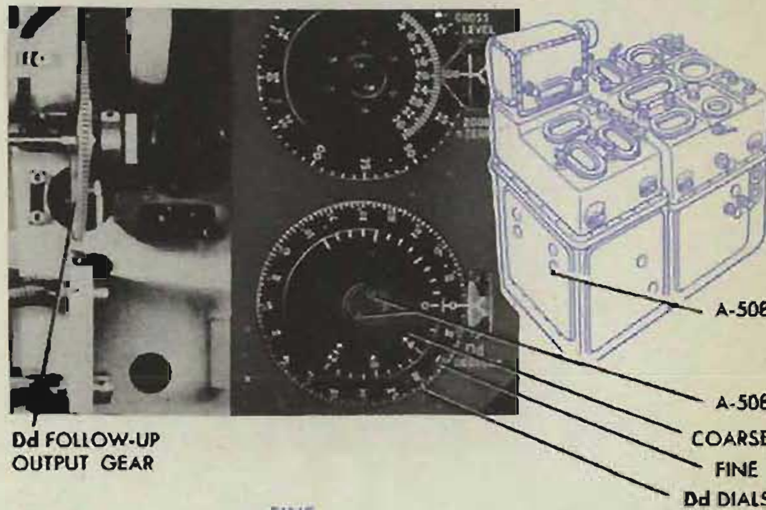
Turn the power OFF.

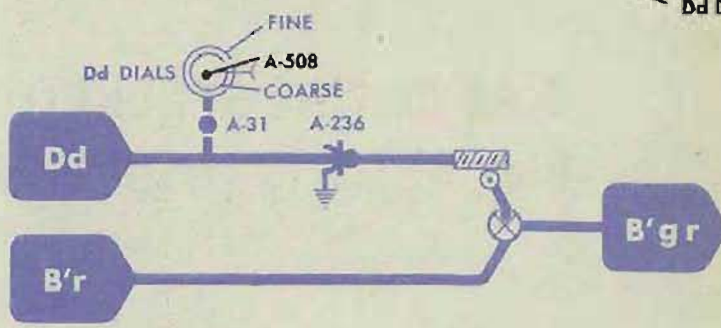
Set the *Dd* dials at 0 by turning the *Dd* follow-up output gearing.

Adjustment

If the coarse *Dd* dial does not read 0, when the fine dial reads 0 at the fixed index, loosen A-508 and slip the coarse dial to 0.

Tighten A-508, and recheck.
Check A-31.





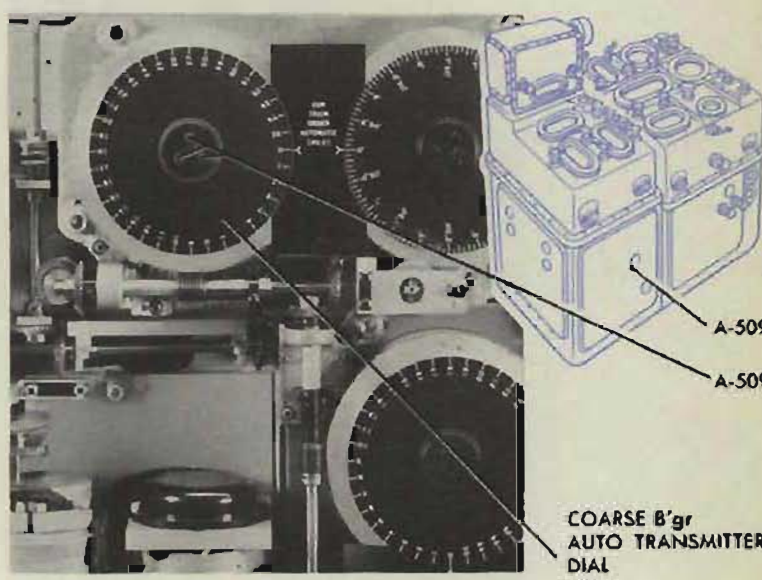
A-509 DIAL to COARSE SYNCHRO — B'gr AUTO TRANSMITTER

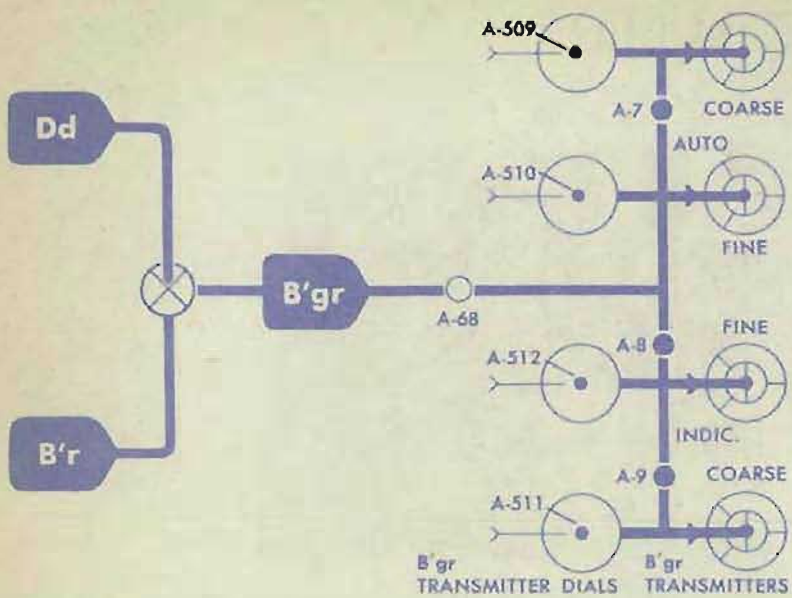
Location

A-509 is under cover 8, on the coarse *B'gr* automatic transmitter dial.

Check

Set the coarse *B'gr* automatic transmitter dial at 0°. The coarse *B'gr* automatic transmitter synchro should be on electrical zero.





Adjustment

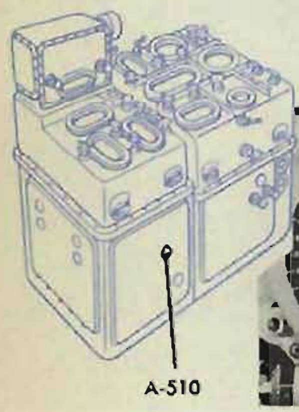
Set the coarse synchro of the transmitter on electrical zero.

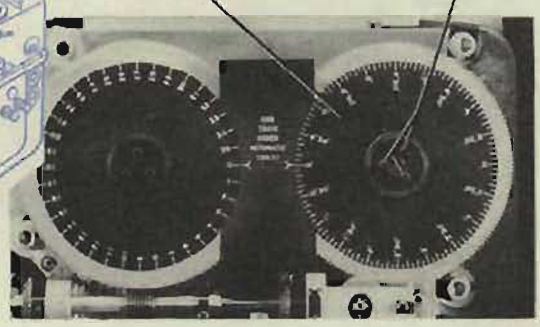
Loosen A-509 and slip the dial to 0.

Tighten A-509, and recheck.

Check A-7.

A-510 DIAL to FINE SYNCHRO — B'gr AUTO TRANSMITTER



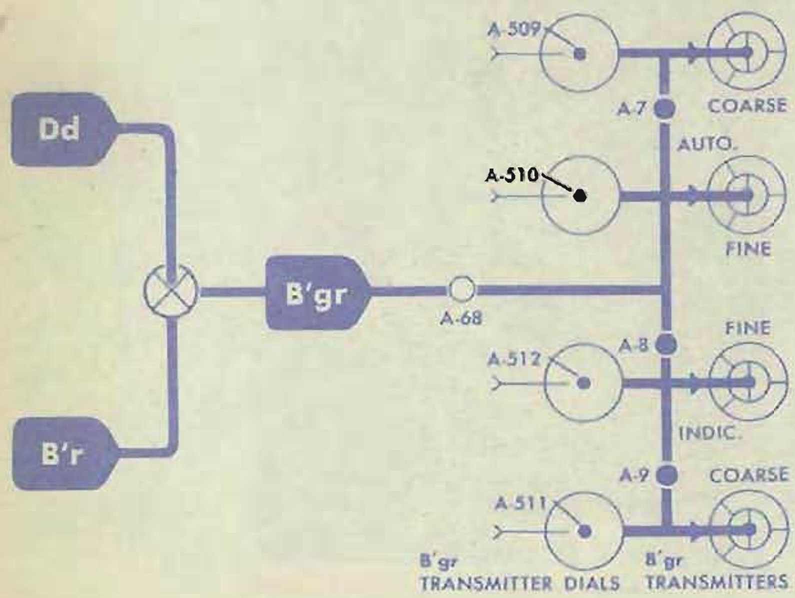


Location

A-510 is under cover 8, on the fine *B'gr* automatic transmitter dial.

Check

Set the fine *B'gr* automatic transmitter dial at 0°. The fine *B'gr* automatic transmitter synchro should be on electrical zero.



Adjustment

Set the fine synchro of the *B'gr* automatic transmitter on electrical zero.

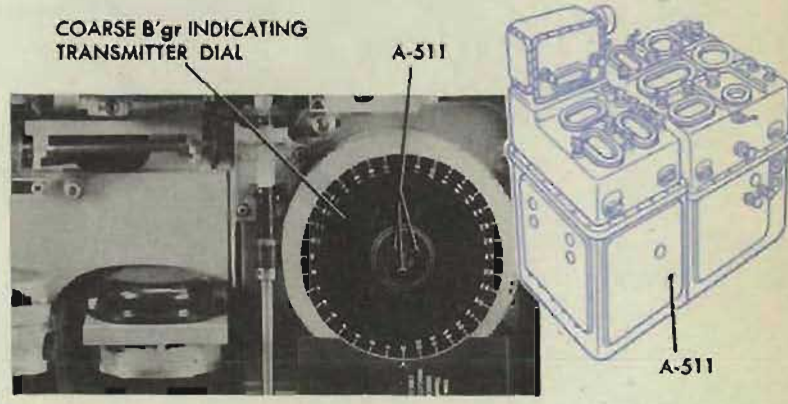
Loosen A-510, and slip the dial to 0°.

Tighten A-510, and recheck.
Check A-7.

A-511 DIAL to COARSE SYNCHRO — B'gr INDICATING TRANSMITTER

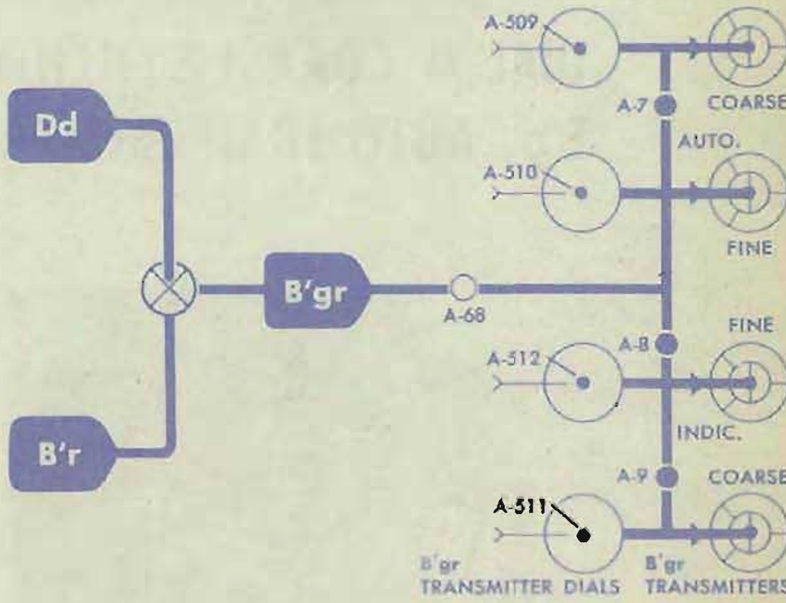
Location

A-511 is under cover 8, on the coarse *B'gr* indicating transmitter dial.



Check

Set the coarse *B'gr* indicating transmitter dial at 0°. The coarse *B'gr* indicating transmitter synchro should be on electrical zero.



Adjustment

Set the coarse synchro of the *B'gr* indicating transmitter on electrical zero.

Loosen A-511, and slip the dial to 0°.

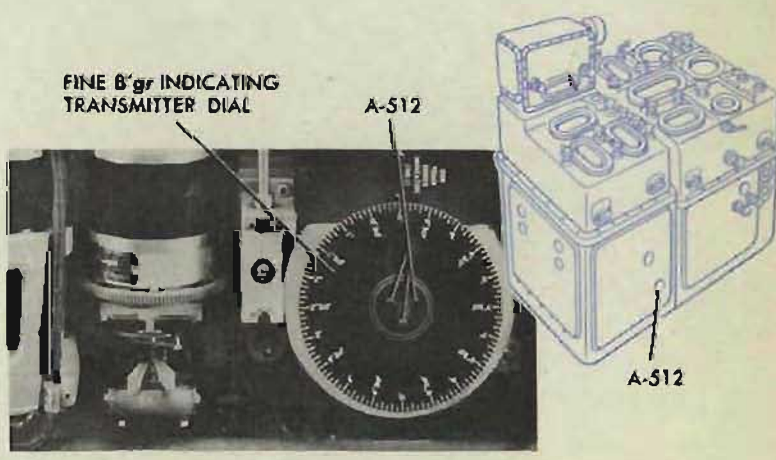
Tighten A-511, and recheck.

Check A-9.

A-512 DIAL to FINE SYNCHRO — B'gr INDICATING TRANSMITTER

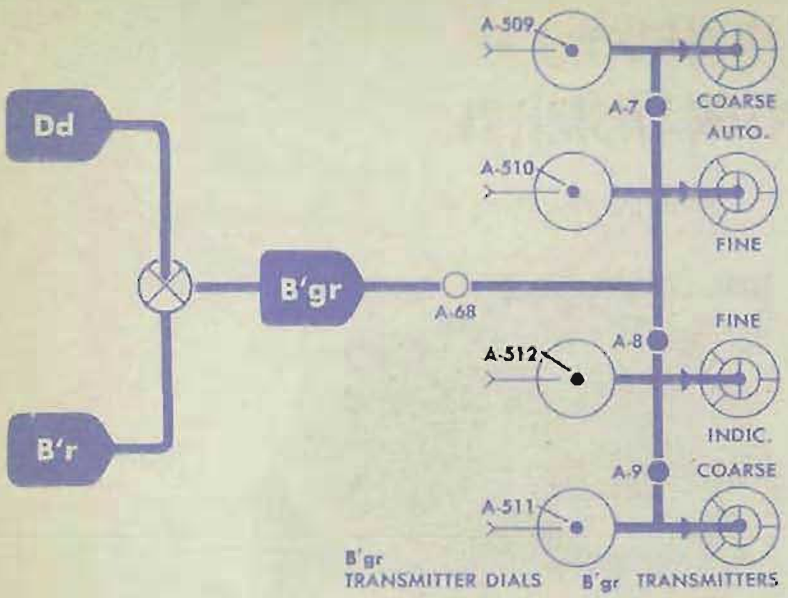
Location

A-512 is under cover 8, on the fine *B'gr* indicating transmitter dial.



Check

Set the fine *B'gr* indicating transmitter dial at 0°. The fine *B'gr* indicating transmitter synchro should be on electrical zero.



Adjustment

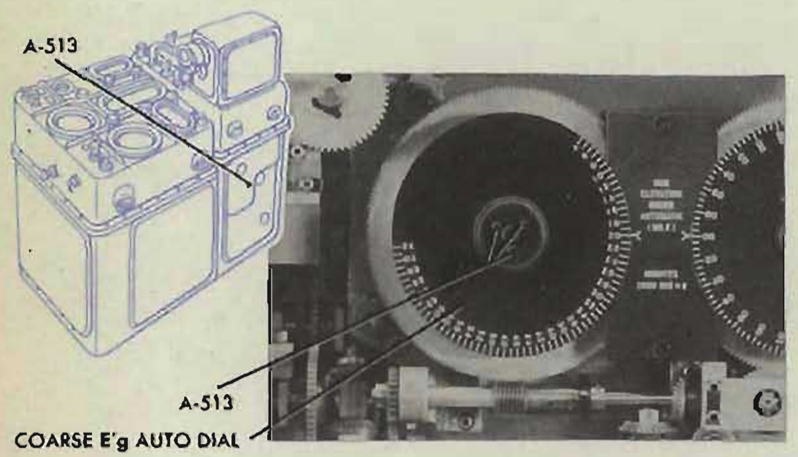
Set the fine synchro of the *B'gr* indicating transmitter on electrical zero.

Loosen A-512, and slip the dial to 0°.

Tighten A-512, and recheck.

Check A-9.

A-513 DIAL to COARSE SYNCHRO — E'g AUTO TRANSMITTER

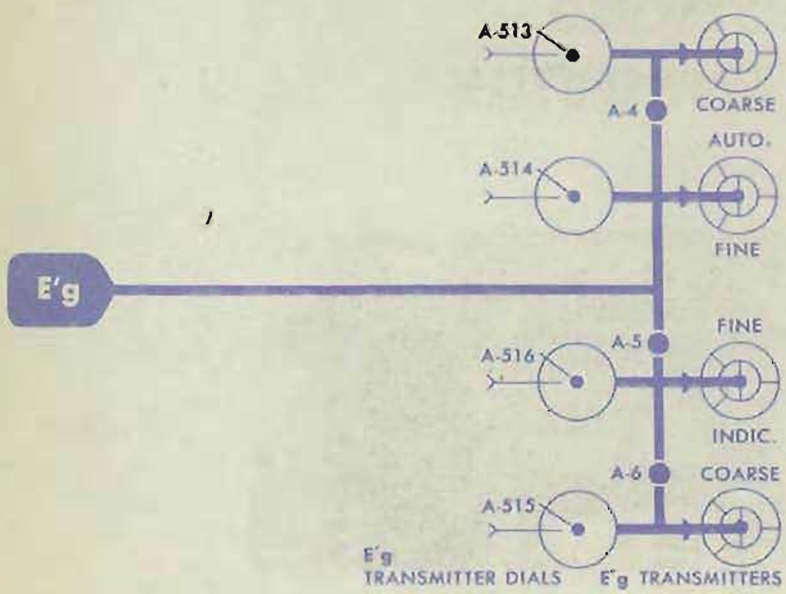


Location

A-513 is under cover 6, on the coarse *E'g* auto transmitter dial.

Check

Set the coarse synchro of the *E'g* auto transmitter on electrical zero. The coarse dial should read 20.



Adjustment

If the coarse *E'g* dial does not read 20 when the coarse synchro is at electrical zero, loosen A-513 and slip the dial to the correct reading.

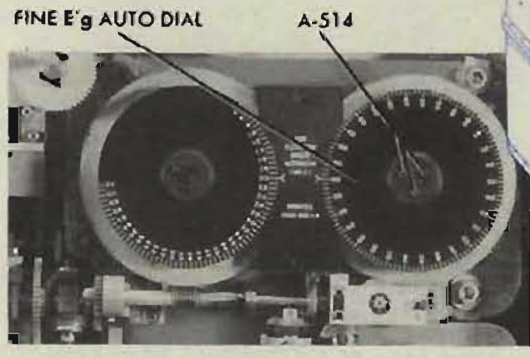
Tighten A-513, and recheck.

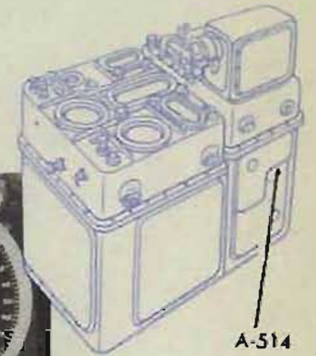
Check A-4.

A-514 DIAL to FINE SYNCHRO — E'g AUTO TRANSMITTER

Location

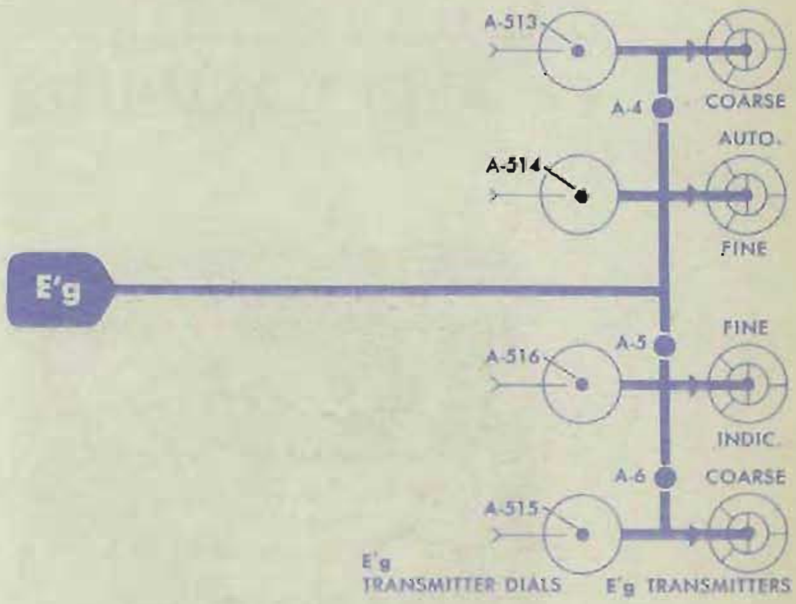
A-514 is under cover 6, on the fine *E'g* automatic transmitter dial.





Check

Set the fine synchro of the *E'g* automatic transmitter on electrical zero. The fine dial should read 00.



Adjustment

If the fine *E'g* auto dial does not read 00, loosen A-514 and slip the dial to 00.

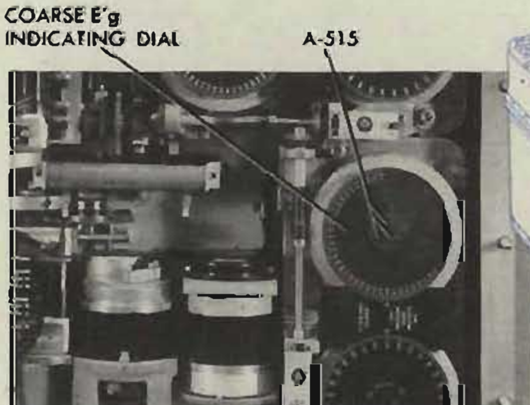
Tighten A-514, and recheck.

Check A-4.

A-515 DIAL to COARSE SYNCHRO — E'g INDICATING TRANSMITTER

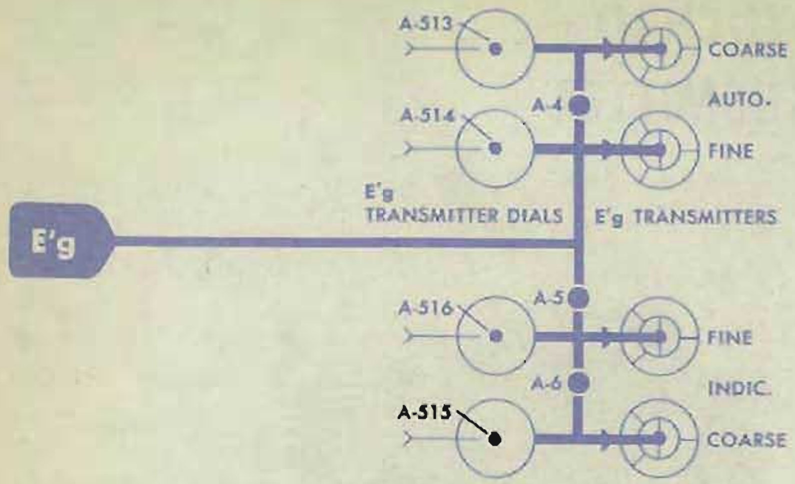
Location

A-515 is under cover 6, on the coarse *E'g* indicating transmitter dial.



Check

Set the coarse synchro of the *E'g* indicating transmitter on electrical zero. The coarse *E'g* indicating dial should read 20.



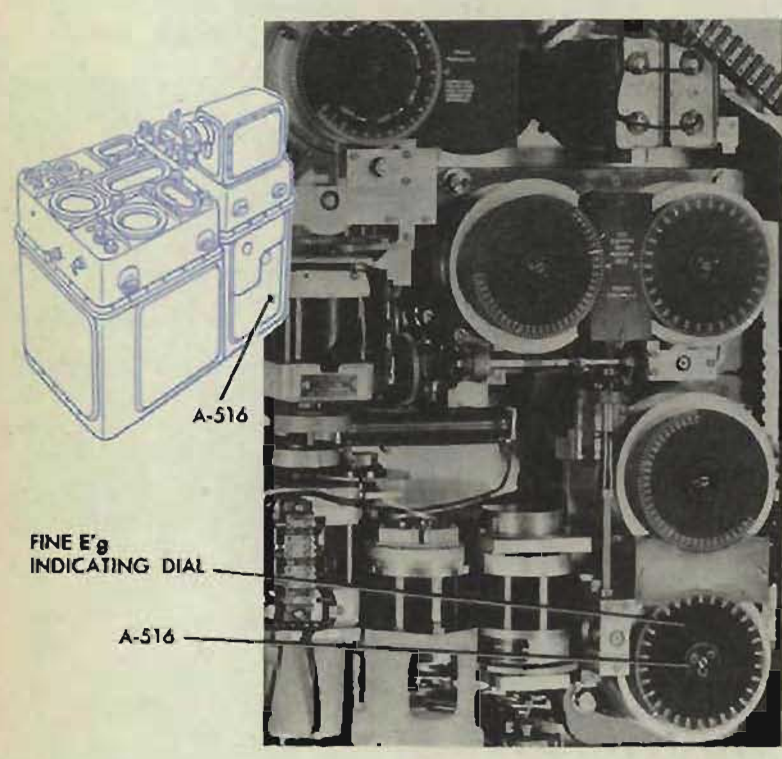
Adjustment

Set the coarse synchro of the transmitter at electrical zero. If the coarse *E'g* indicating dial does not read 20, loosen A-515 and slip the *E'g* dial to 20.

Tighten A-515, and recheck.

Check A-6.

A-516 DIAL to FINE SYNCHRO — E'g INDICATING TRANSMITTER

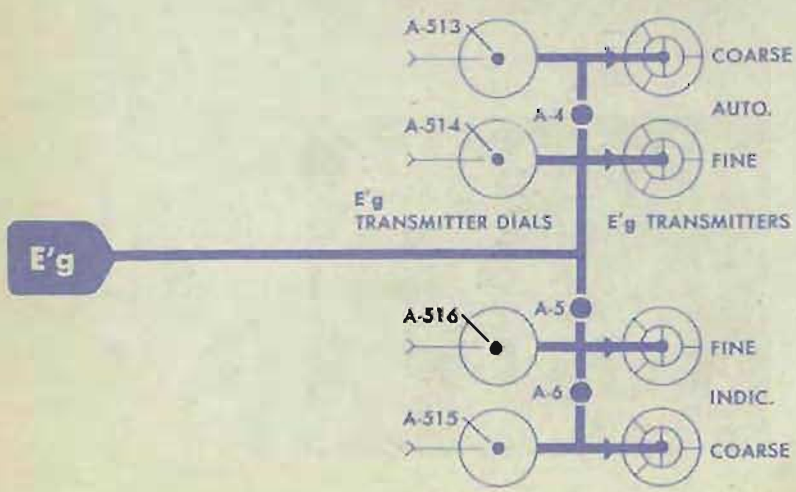


Location

A-516 is under cover 6, on the fine *E'g* indicating transmitter dial.

Check

Set the fine synchro of the transmitter on electrical zero. The fine *E'g* indicating dial should read 00.



Adjustment

Set the fine synchro on electrical zero. If the fine indicating *E'g* dial does not read 00, loosen A-516 and slip the dial to 00.

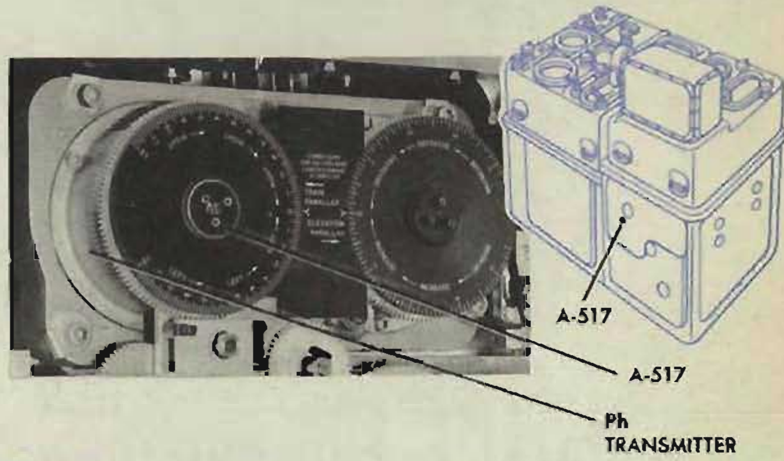
Tighten A-516, and recheck.

Check A-6.

A-517 DIAL to SYNCHRO – Ph TRANSMITTER

Location

A-517 is under cover 6, on the *Ph* transmitter dial.



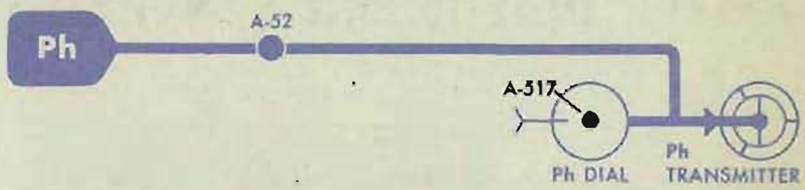
Check

Loosen A-52.

Set the synchro of the *Ph* transmitter on electrical zero. The *Ph* dial should read 0°.

Adjustment

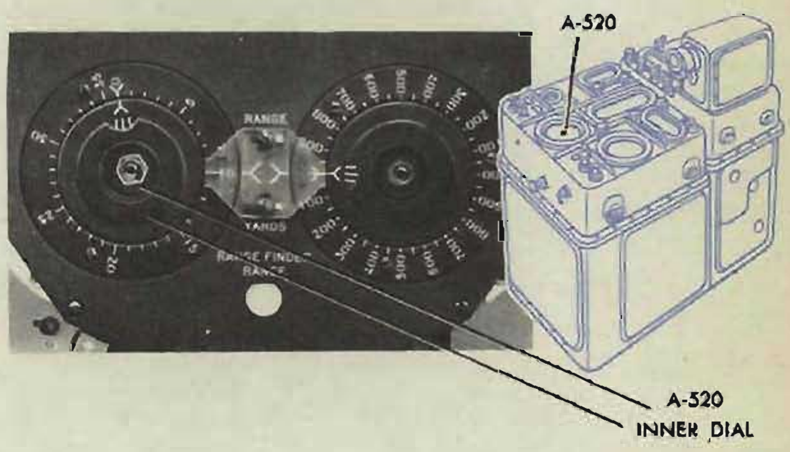
If the *Ph* dial does not read 0°, loosen A-517 and slip the *Ph* dial to its proper value.
Tighten A-517, and recheck.
Readjust A-52.



A-520 DIAL to COARSE SYNCHRO – R RECEIVER

Location

A-520 is under cover 1, on the coarse synchro of the *R* receiver.

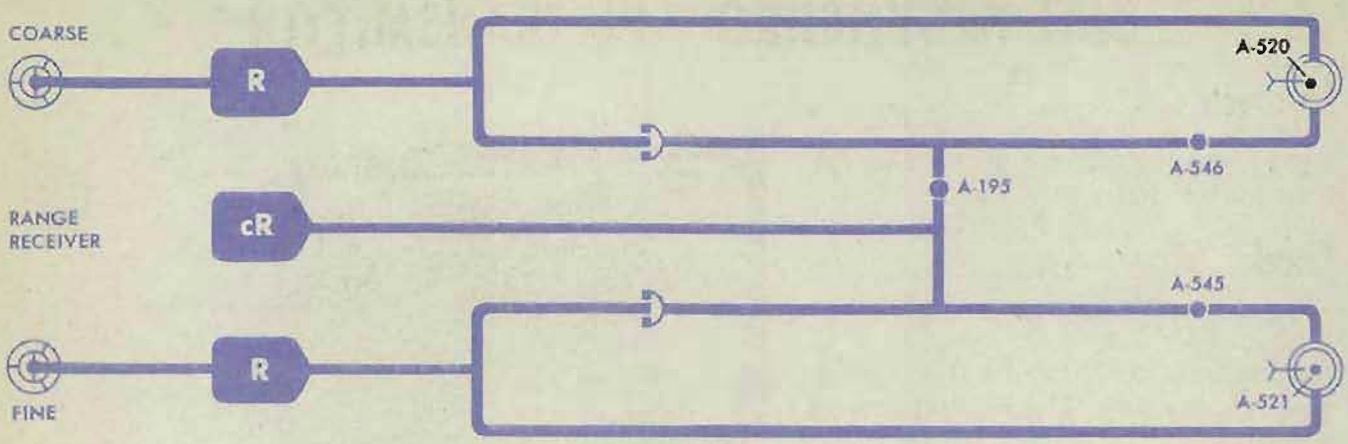


Check

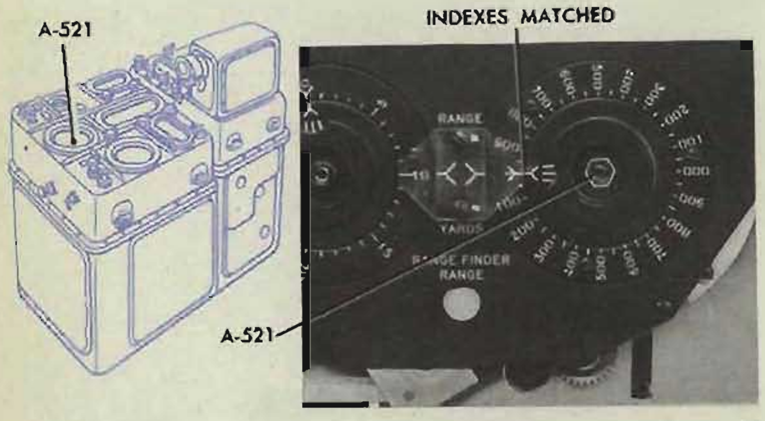
Transmit 10,000 yards range from the director. Check that there is torque on the synchro rotor by trying to turn the inner dial.
Turn the range rate control switch to MANUAL.
Set the coarse ring dial at 10,000 yards.
The index on the inner dial should match the 0 index on the ring dial.

Adjustment

If the index on the inner dial does not match the index on the ring dial, loosen A-520 with a synchro dial wrench. Move the inner dial until it matches.
Tighten A-520, and recheck.
Check A-521, A-546, and A-195.



A-521 DIAL to FINE SYNCHRO — R RECEIVER



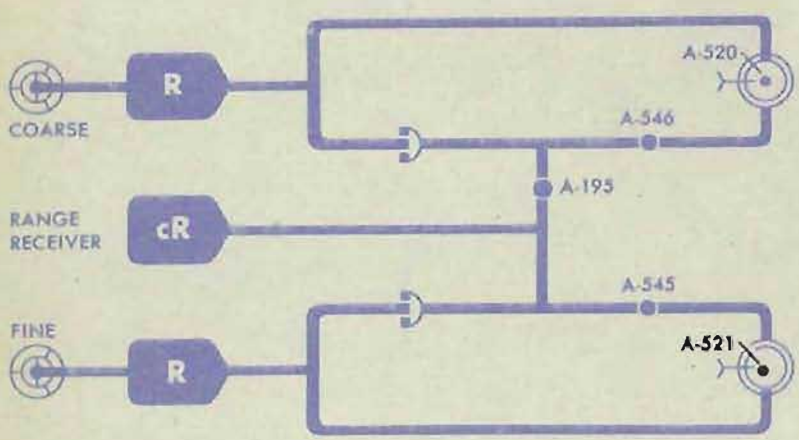
Location

A-521 is under cover 1, on the fine synchro of the *R* receiver.

Check

Transmit 10,000 yards range from the director.
Turn the range rate control switch to MANUAL.
Set the fine range ring dial index at the fixed index.

The index on the fine inner dial should match the index on the ring dial.



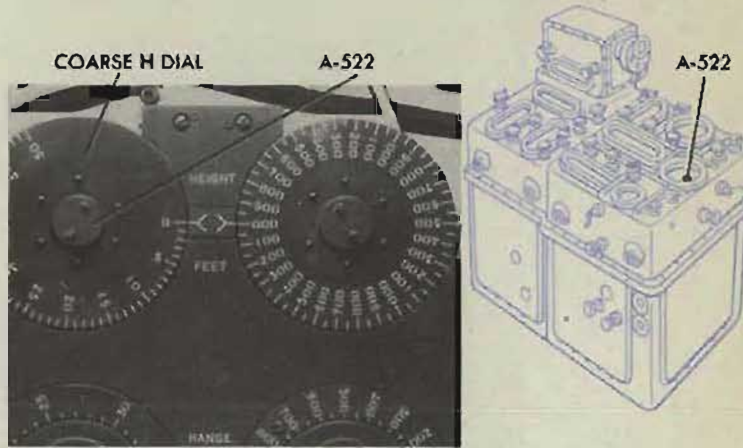
Adjustment

If the indexes do not match, loosen A-521 with a synchro dial wrench. Move the inner dial until the indexes match.

Tighten A-521, and recheck.

Check A-545.

A-522 COARSE H DIAL to HEIGHT COMPUTER



Location

A-522 is under cover 1, on the coarse *H* dial.

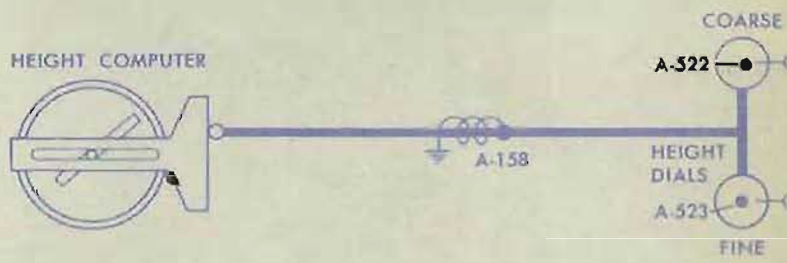
Check

Set E at 0°.
Set *cR* at 0 yards.
The coarse *H* dial should read 0 feet.

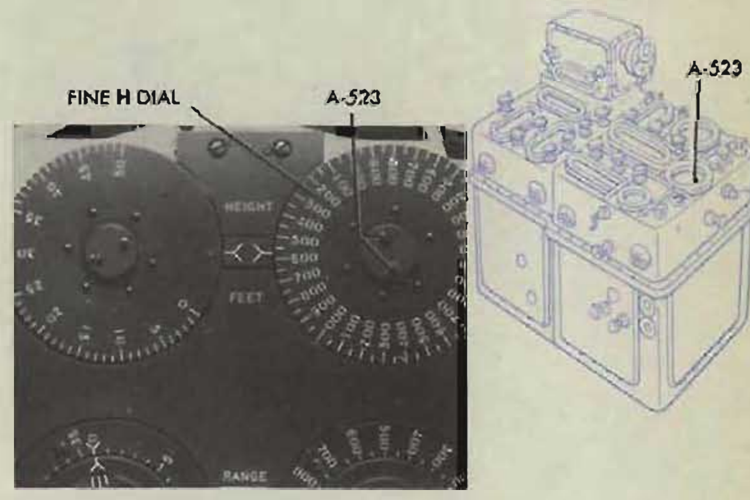
Adjustment

If the coarse *H* dial does not read 0, loosen A-522 and slip the dial to 0.

Tighten A-522, and recheck.



A-523 FINE H DIAL to HEIGHT COMPUTER



Location

A-523 is under cover 1, on the fine *H* dial.

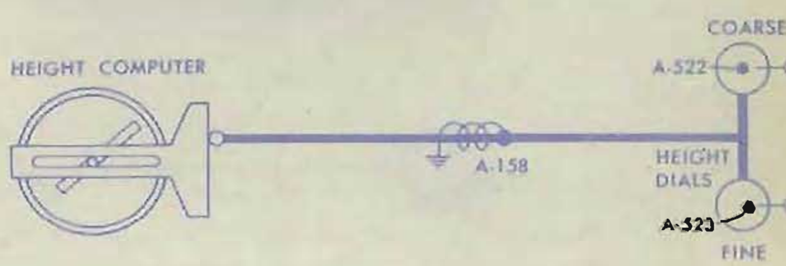
Check

Set *cR* at 0 yards.
Set *E* at 0°.
The fine *H* dial should read 000.

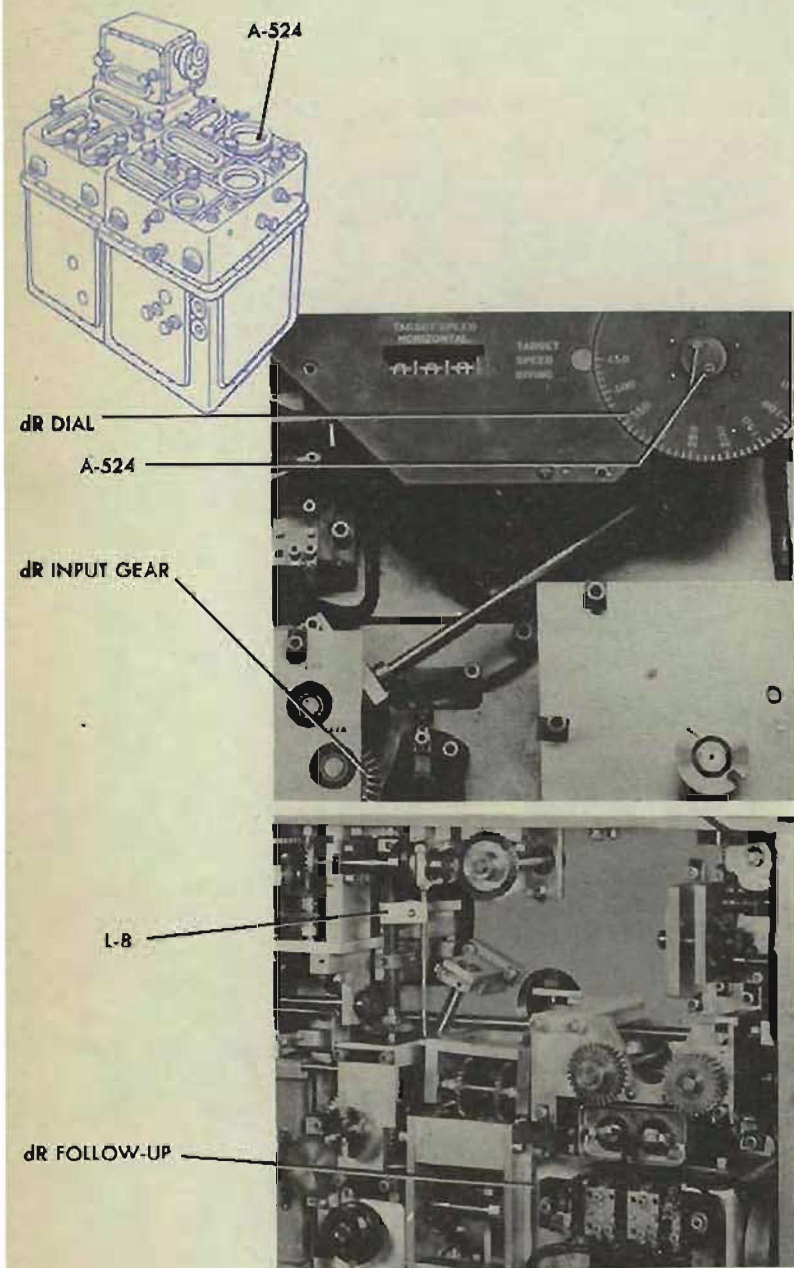
Adjustment

If the fine *H* dial does not read 000, loosen A-523 and slip the dial to 000.

Tighten A-523, and recheck.



A-524 dR DIAL to L-8



Location

A-524 is under cover 1, on the *dR* dial.

L-8 is under cover 1, above the gearing on the *dR* follow-up. It is mounted vertically, with the lower limit at the bottom.

Check

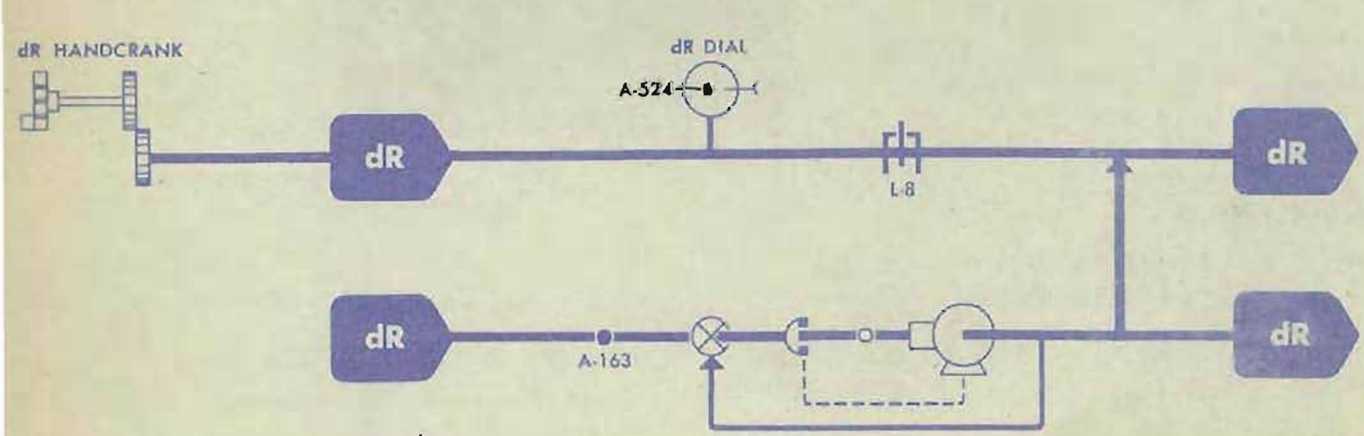
Turn the power OFF.

Turn *dR* until L-8 reaches the lower limit. The *dR* dial should read −450 on the inscribed side of the dial.

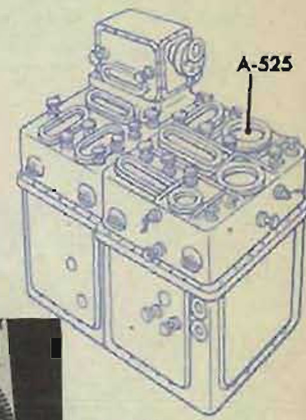
Adjustment

If the dial does not read the proper value, loosen A-524.
Hold the *dR* line against the stop and slip the *dR* dial to −450 knots.
Tighten A-524 and recheck at the upper limit. The *dR* dial should read +450 knots on the blank side of the dial.

Check A-163.



A-525 dH DIAL to L-4



Location

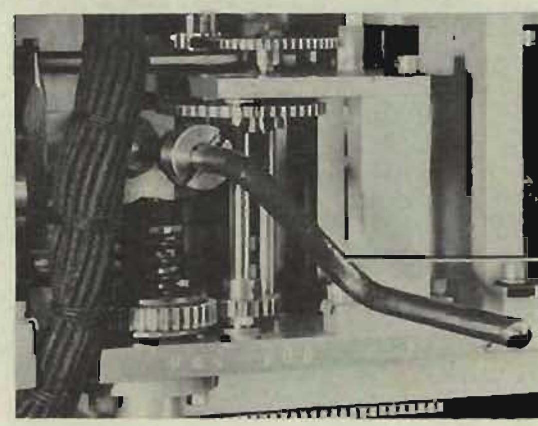
A-525 is under cover 1, on the *dH* dial.

L-4 is under cover 1 on the underside of the top plate. Its lower limit is toward the left.

Check

Run the *dH* line by hand to either limit.

At the upper limit, the *dH* dial should read CLIMB 150, and at the lower limit it should read DIVE 250.



Note

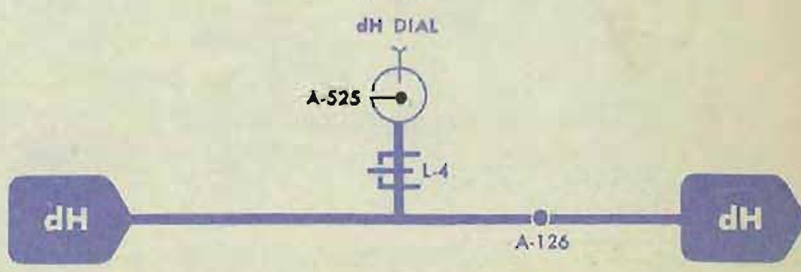
If either limit of L-4 cannot be reached, A-126 may be causing a restriction. If so, loosen and readjust it later.

Adjustment

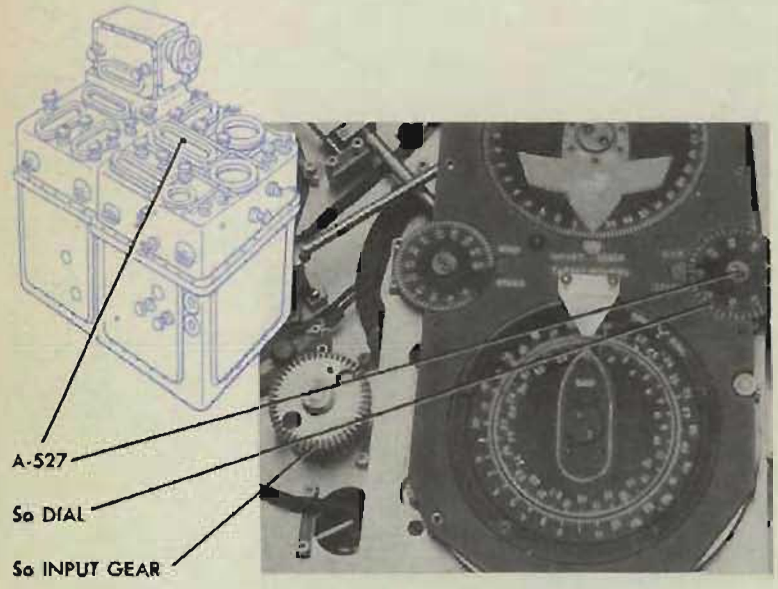
If the *dH* dial does not read the proper value at its limits, loosen A-525.
Hold the *dH* line against either limit and slip the *dH* dial to the proper value.
Tighten A-525, making sure that the *dH* line is held against the stop.

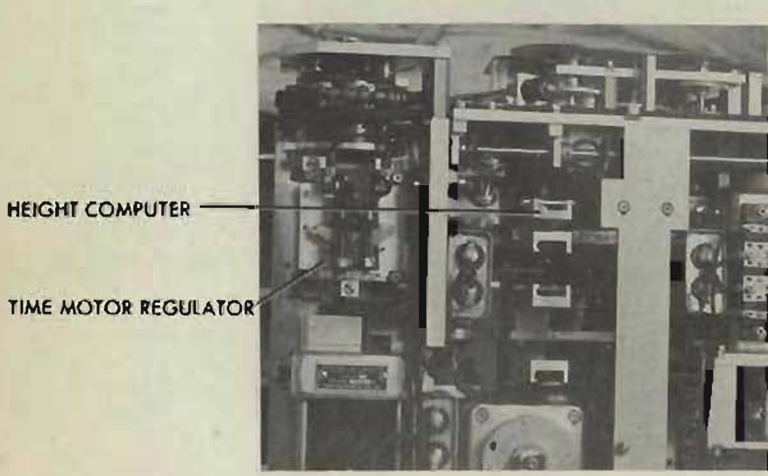
Recheck at the other limit of L-4.

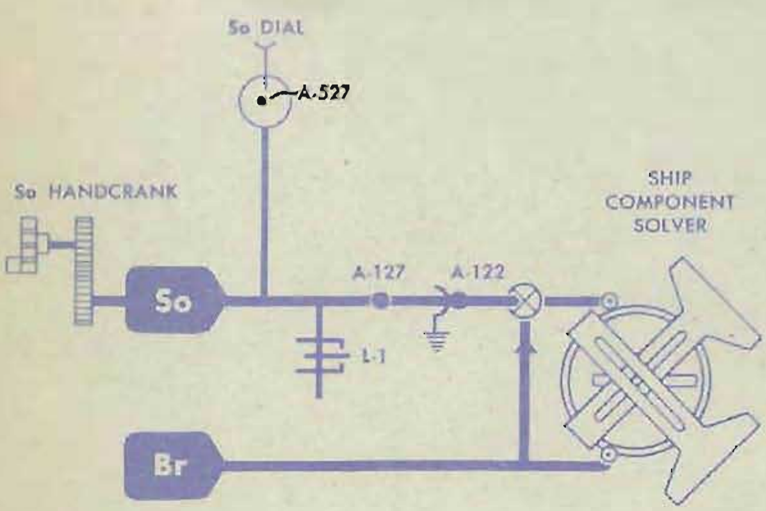
Check A-126.



A-527 So DIAL to L-1







Location

A-527 is under cover 1, on the *So* dial.

L-1 is under cover 1, to the right of the ship dial group, under the top plate. It may be seen through the opening to the rear of the time motor regulator, above the height computer.

Check

The *So* dial should read 0 knots at the lower limit and 45 knots at the upper limit.

CAUTION

If any restriction is felt in the line before either limit is reached, loosen A-127 and readjust it later.

Adjustment

If the *So* dial does not read 0 knots at the lower limit and 45 knots at the upper limit, loosen A-527. Turn the *So* input gear to hold the line against the lower limit. Slip the dial to 0.

Tighten A-527, and recheck at the upper limit.

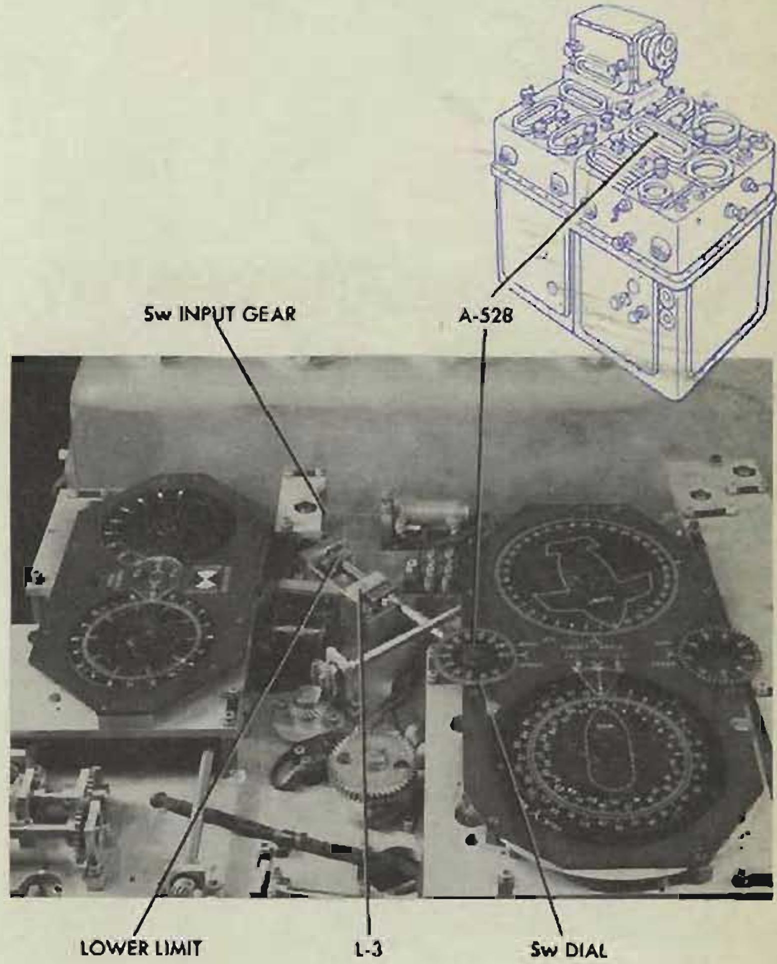
Check A-127 and A-212.

A-528 Sw DIAL to L-3

Location

A-528 is under cover 1, on the *Sw* dial.

L-3 is near the *Sw* input gear with its lower limit toward the input gear.



Check

The limits for *Sw* are 0 and 60 knots.

Turn the *Sw* input gear until the lower limit of the stop is reached. The *Sw* dial should read 0 knots.

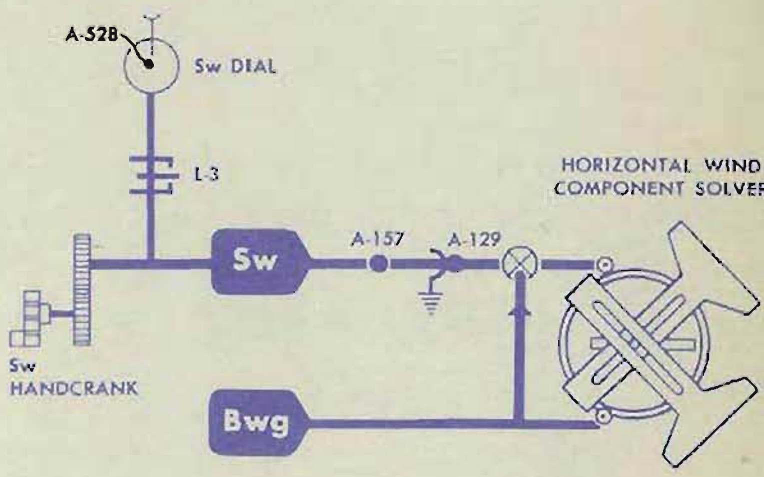
CAUTION

If either end of the limit stop cannot be reached, A-157 may be upset and causing a restriction. Loosen A-157, and readjust it later.

Adjustment

If the *Sw* dial does not read 0 knots when the stop is at its lower limit, loosen A-528. Hold the line against the stop and slip the dial to 0.

Tighten A-528.

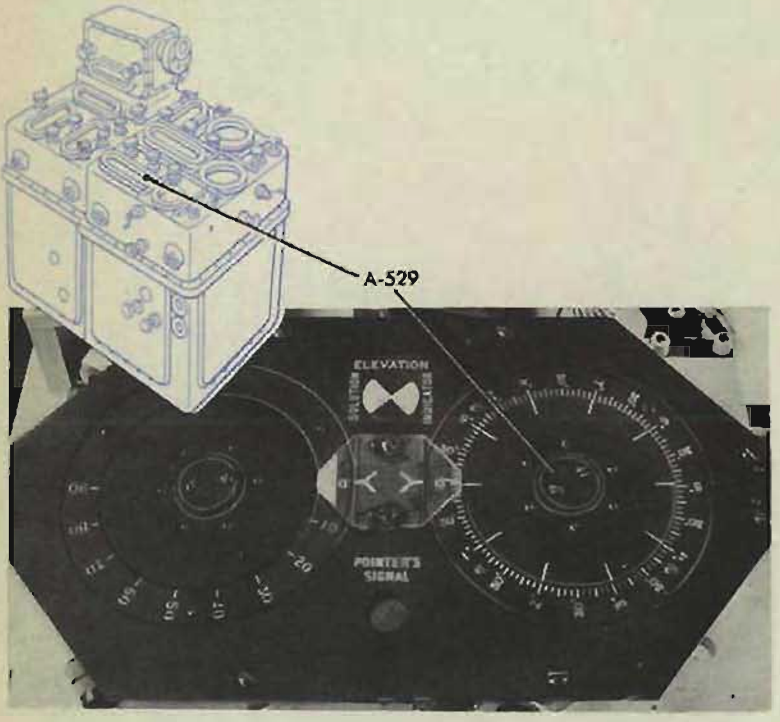


Recheck

Run *Sw* to the upper limit. The *Sw* dial should read 60 knots.

Check A-157.

A-529 FINE cE DIAL to FINE E DIAL



Location

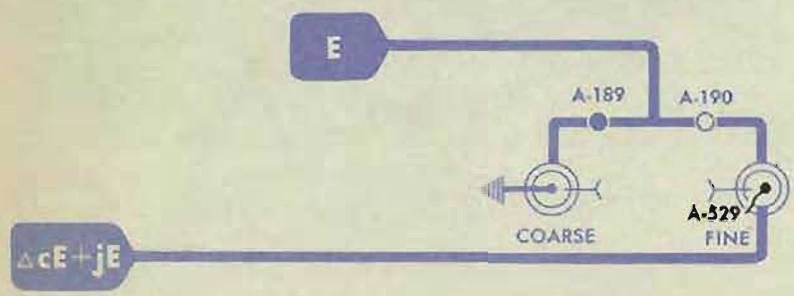
A-529 is under cover 1, on the fine *cE* dial.

Check

Set *E* at 0°.
Turn the power ON.
Turn the control switch to AUTO.
One index on the fine *cE* dial should match the fixed index, within ± 4 minutes.

On Ser. Nos. 100 and lower, the pointer should match the fixed index, within ± 4 minutes.

NOTE: The tolerance of ± 4 minutes allows for the wide contact spacing on the *jE* follow-up.



Adjustment

If one *cE* index, or the pointer, does not match the fixed index, loosen A-529, and slip the dial to the matched position. (Split the 8 minutes' dead space.)

Tighten A-529 and recheck.

A-530 COARSE cE DIAL to COARSE E DIAL

Location

A-530 is under cover 1, on the coarse *cE* dial, on instruments with Ser. Nos. 100 and lower.

Check

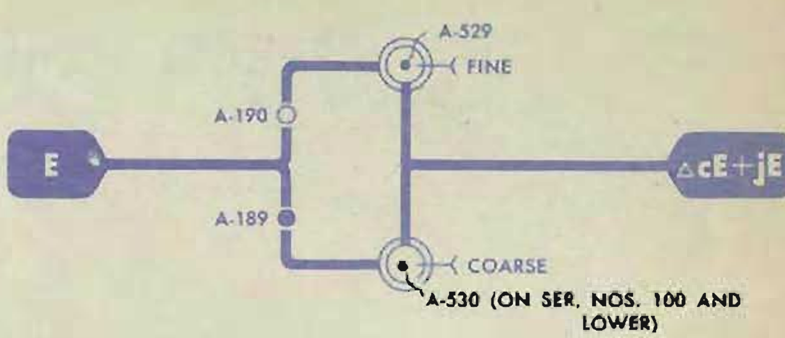
Set *E* at 0°.
Turn the power ON.
Turn the control switch to AUTO.
One graduation on the coarse inner dial should match the 0 of the ring dial.

Adjustment

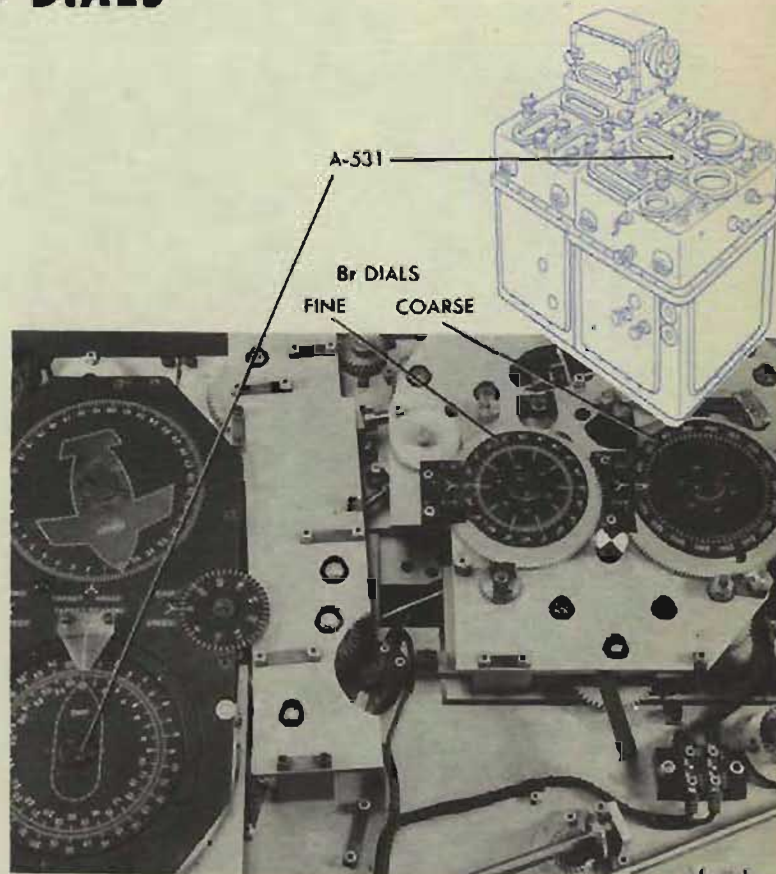
If one graduation does not match the 0 of the ring dial loosen A-530.

Slip the dial to the matched position.

Tighten A-530, and recheck.



A-531 SHIP DIAL to Br DIALS



Location

A-531 is under cover 1, on the ship dial.

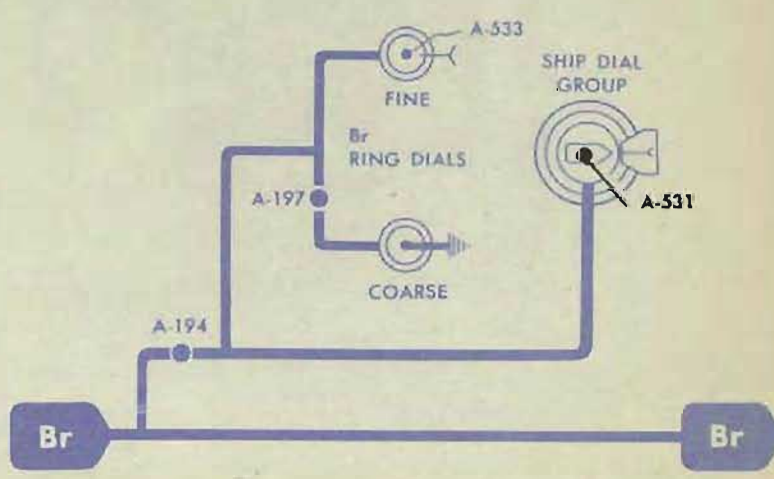
Check

Turn the power ON.
Set *Br* at 0°.
The ship dial should read 0° at the fixed index when the *Br* dials read 0°.

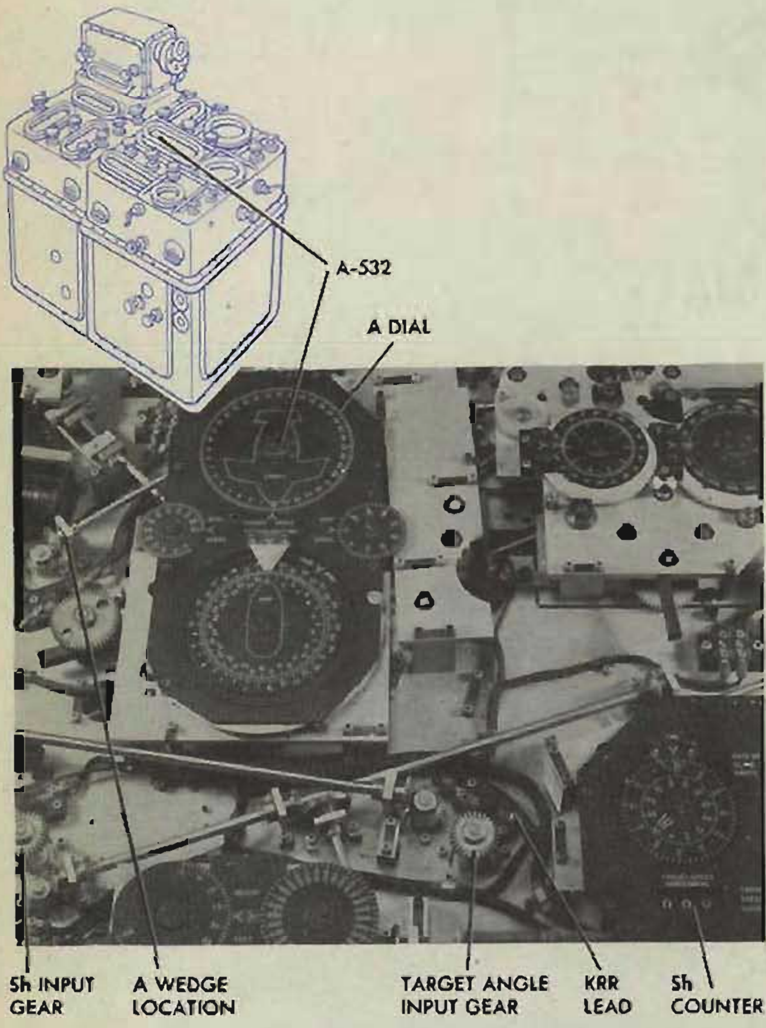
Adjustment

If the ship dial does not read 0°, wedge the *Br* line at 0° and loosen A-531. Slip the ship dial to read 0°.

Tighten A-531 and recheck by moving *Br* off 0° and bringing it back on. Observe whether the ship dial readings continuously match the *Br* dial readings.



A-532 A DIAL to TARGET COMPONENT SOLVER



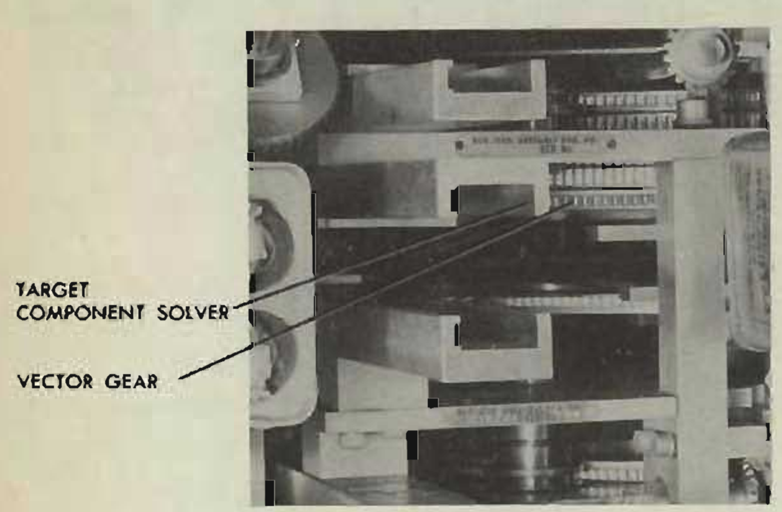
Location

A-532 is under cover 1, on the *A* dial.

Check

Disconnect the KRR lead on the target angle push-button switch.
Turn the power ON.
Set *A* at 0°, and wedge the input gear.
The vector gear slot of the target component solver should be toward the front.

The vector gear can be seen through an access at the right side of the front top section, in front of the *RdBs* follow-up. The target component solver is the second component solver from the top.



Set *Sh* at 0 knots.

Mark the *RdBs* follow-up output gear for use as an indicator.

Run *Sh* from 0 to 400 knots.

The follow-up indicator marks should remain matched for full travel of *Sh*.

Adjustment

If the marks do not remain matched, remove the wedges from the *A* line and turn the *A* input until the marked gear has returned to its original position.

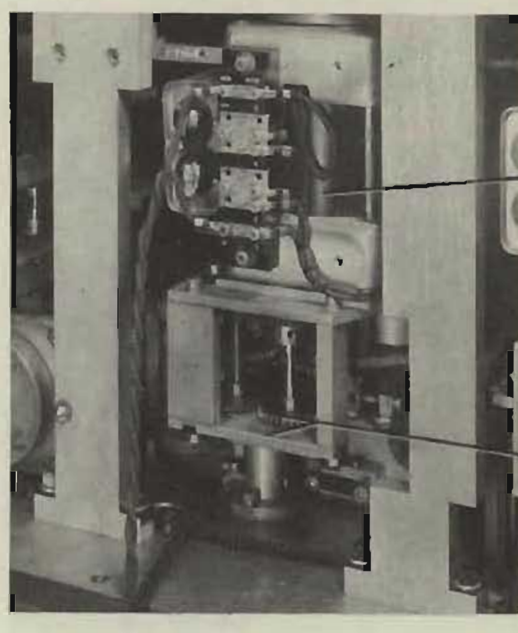
When the error is corrected, wedge the *A* line.

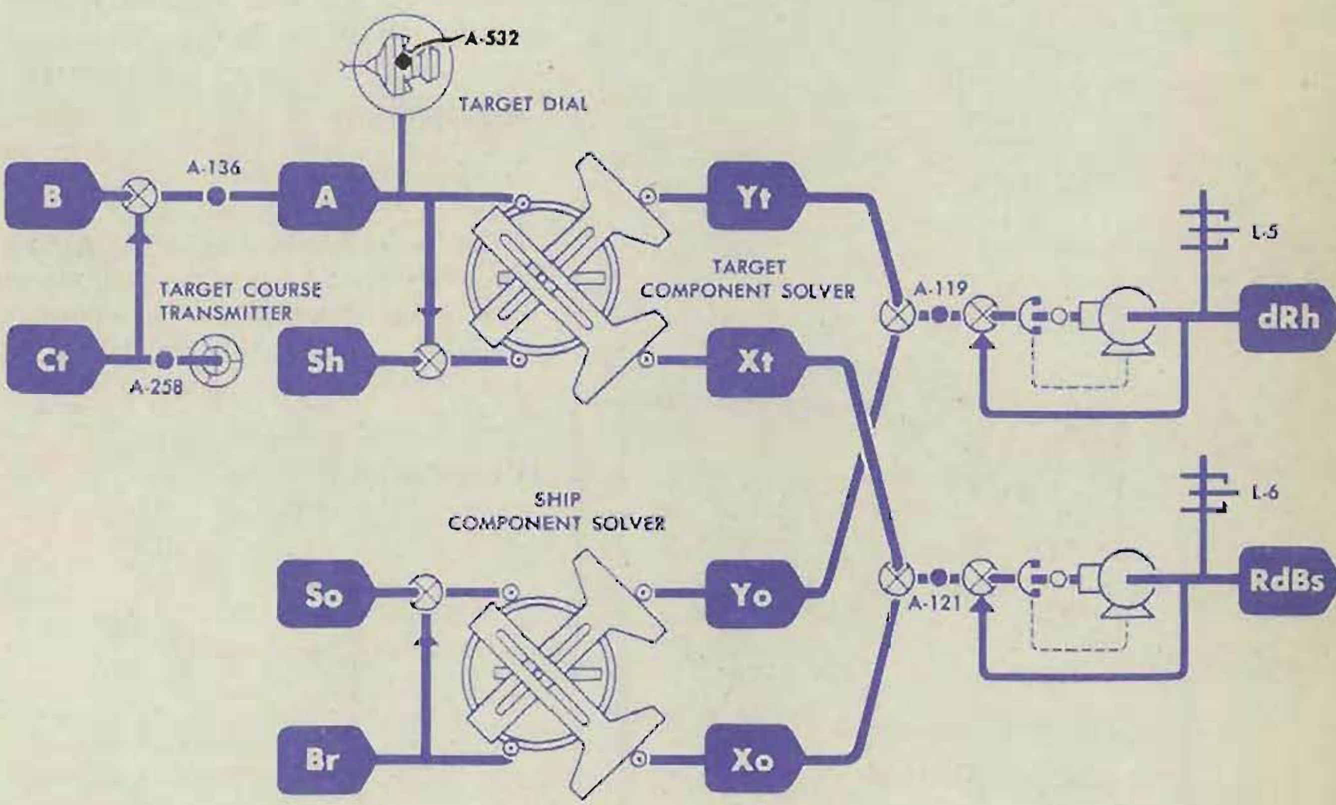
Loosen A-532 and set the *A* dial at 0°.

Tighten A-532 and recheck. The final error should be less than one-half-tooth movement of the indicating gear. Turn *A* to 180° and repeat the check, splitting any lost motion.

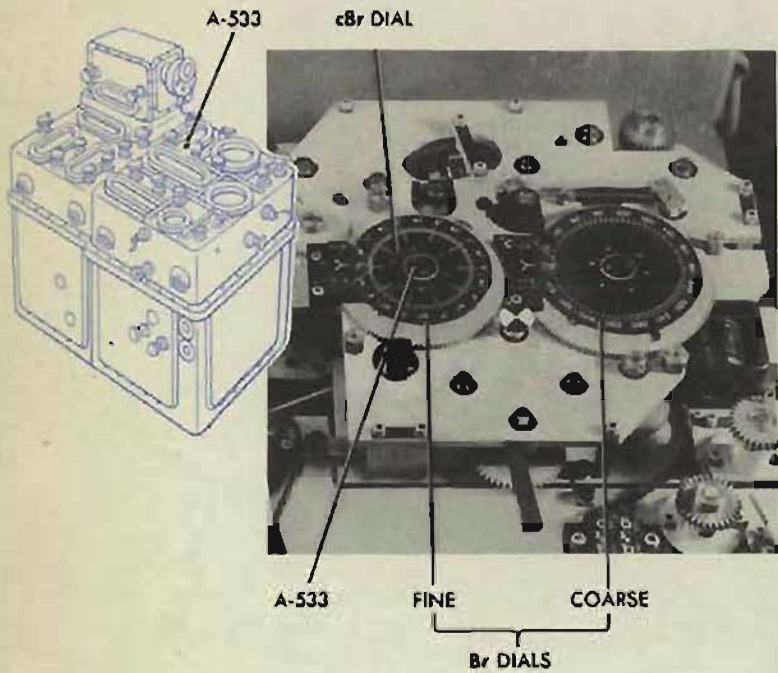
Remove all wedges, and replace the KRR lead.

Check A-119, A-121, A-136, and A-258.





A-533 FINE cBr DIAL to FINE Br DIAL



Location

A-533 is under cover 1, on the fine *cBr* dial.

Check

Turn the power ON.
Set *Br* at 0°.
Turn the control switch to AUTO.
One of the index marks of the fine *cBr* dial should match the 0° graduation of the fine *Br* dial, within ± 7 minutes.

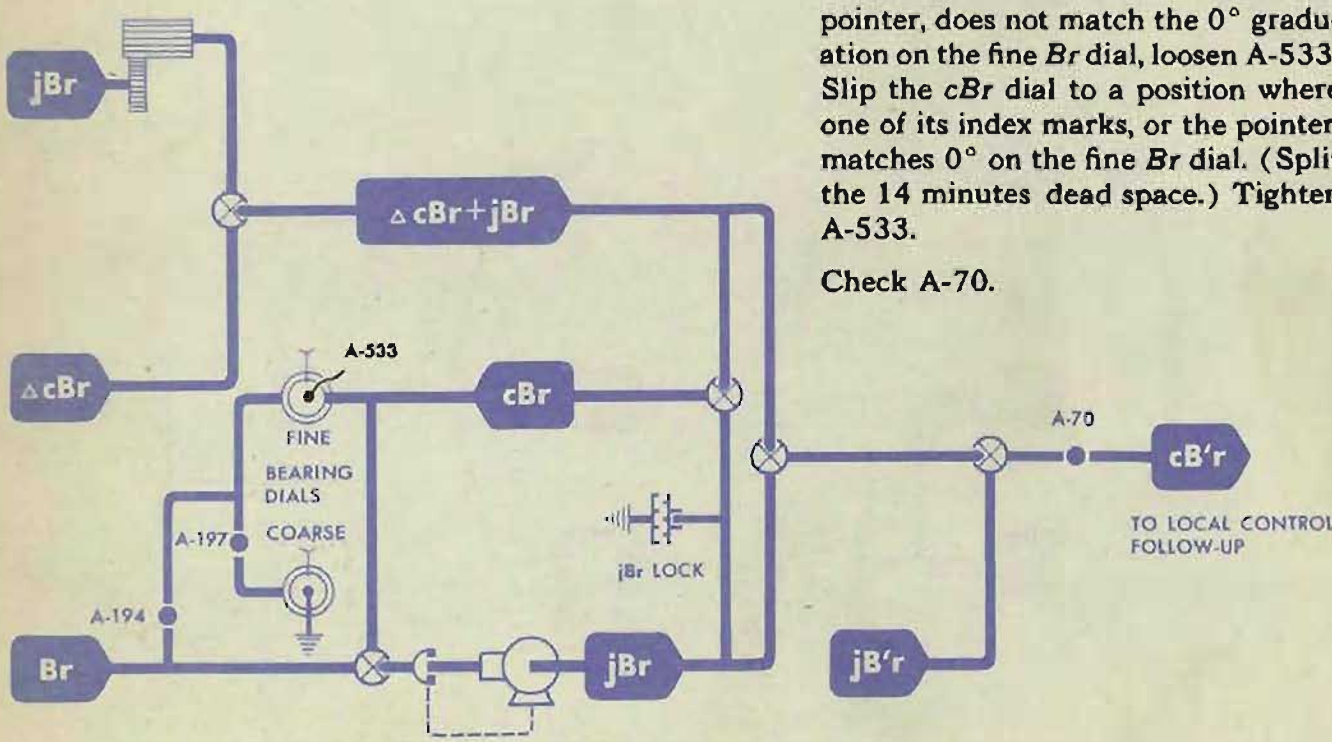
On instruments with Ser. Nos. 100 and lower, the pointer should match the 0° graduation of the ring dial within ± 7 minutes.

NOTE: The tolerance of ± 7 minutes allows for the wide contact spacing on the *jBr* follow-up.

Adjustment

If one of the *cBr* index marks, or the pointer, does not match the 0° graduation on the fine *Br* dial, loosen A-533. Slip the *cBr* dial to a position where one of its index marks, or the pointer, matches 0° on the fine *Br* dial. (Split the 14 minutes dead space.) Tighten A-533.

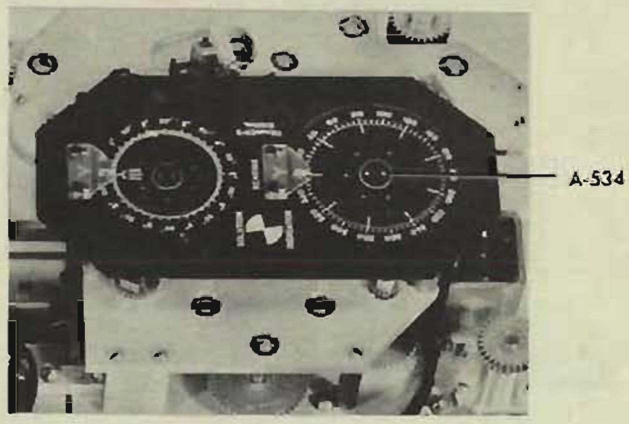
Check A-70.



A-534 COARSE cBr DIAL to COARSE Br DIAL

Location

A-534 is under cover 1, on the coarse *cBr* dial, on instruments with Ser. Nos. 100 and lower.

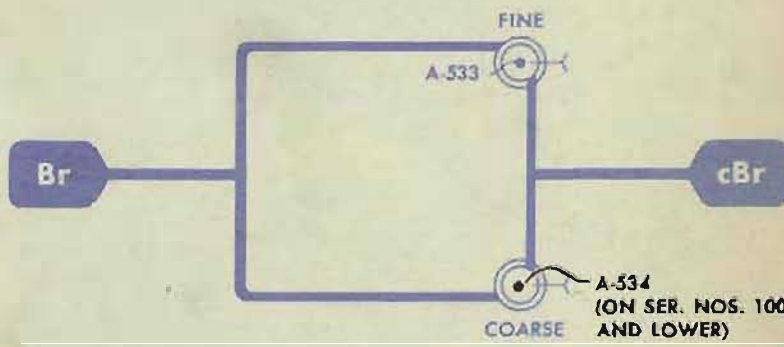


Check

Turn the power ON.
Set *Br* at 0°.
Turn the control switch to AUTO.
One graduation of the coarse inner dial should match the 0 of the ring dial.

Adjustment

If one graduation does not match the 0 of the ring dial, loosen A-534.
Slip the dial to the correct position.
Tighten A-534, and recheck.



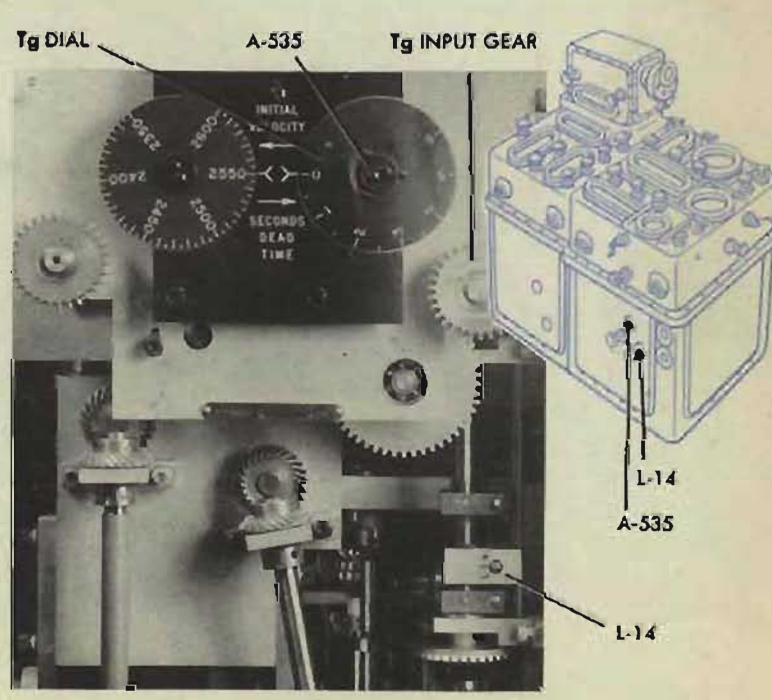
A-535 Tg DIAL to L-14, or L-38

Location

A-535 is under cover 3, on the *Tg* dial.

L-14 is below the *Tg* input gear, in a vertical position with its lower limit at the bottom.

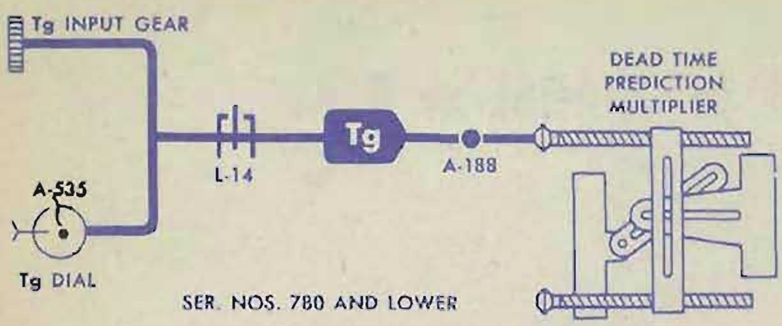
L-38 is on a spur gear behind the *Tg* dial, on Ser. Nos. 781 and higher.

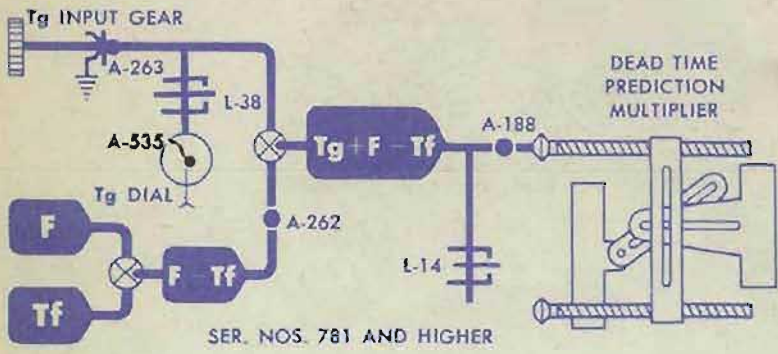


Check

The *Tg* dial should read 0 seconds at the lower limit and 6 seconds at the upper limit.

Turn the *Tg* input gear and read the limit values on the *Tg* dial.





CAUTION

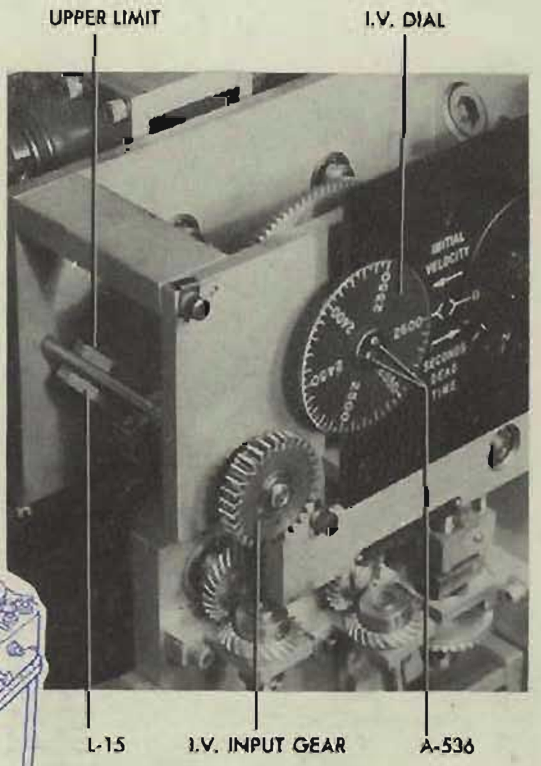
If either limit cannot be reached, loosen A-188.

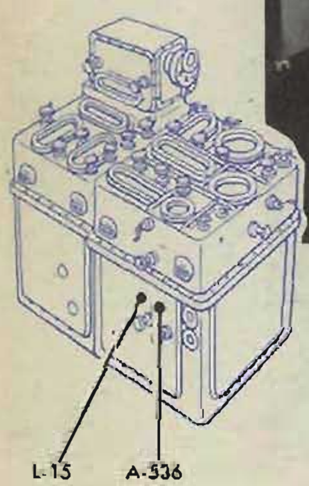
Adjustment

If the *Tg* dial does not read the proper values, hold the line against the lower limit, loosen A-535, and slip the *Tg* dial to 0.
Tighten A-535, and recheck at the upper limit.

Check A-188 and A-262.

A-536 I. V. DIAL to L-15





Location

A-536 is under cover 3, on the *I.V.* dial.

L-15 is under cover 3, behind the *I.V.* input gear. The upper limit is at the inner end.

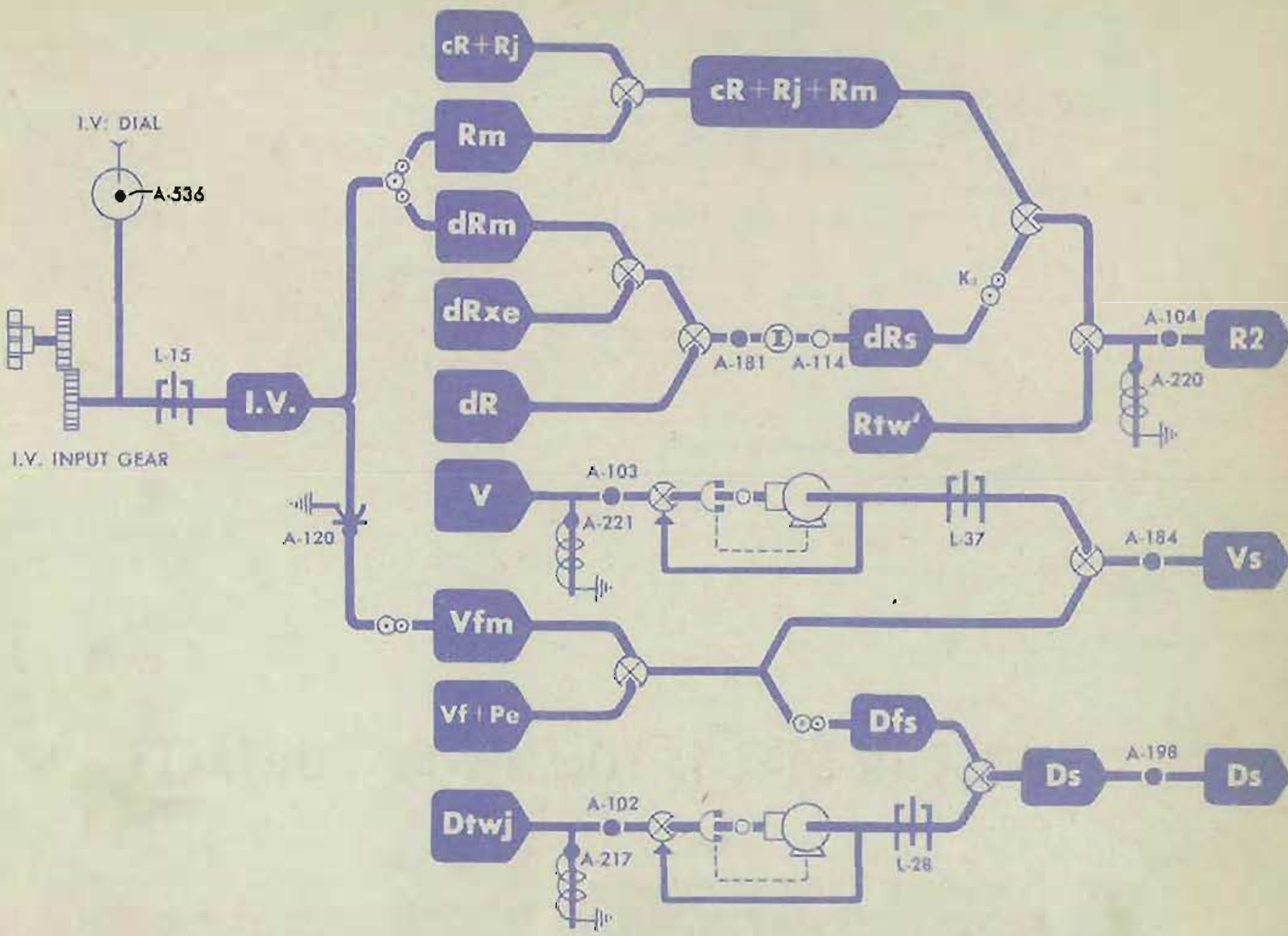
Check

On most instruments the limits are 2350 f.s. and 2600 f.s.
On Mods 8 and 12, the limits are 2400 and 2650 f.s.
Turn *I.V.* to each limit. If the *I.V.* dial reads incorrectly, readjust A-536.

Adjustment

Loosen A-536.
Hold the *I.V.* line against one limit and slip the dial to the correct value.
Tighten A-536, and recheck at the other limit.

Check A-102, A-103, A-104, A-181, A-198 and A-184.
On instruments with Ser. Nos. 781 and higher, also check A-132.



A-545 FINE cR DIAL to FOLLOW-UP CONTACTS

Location

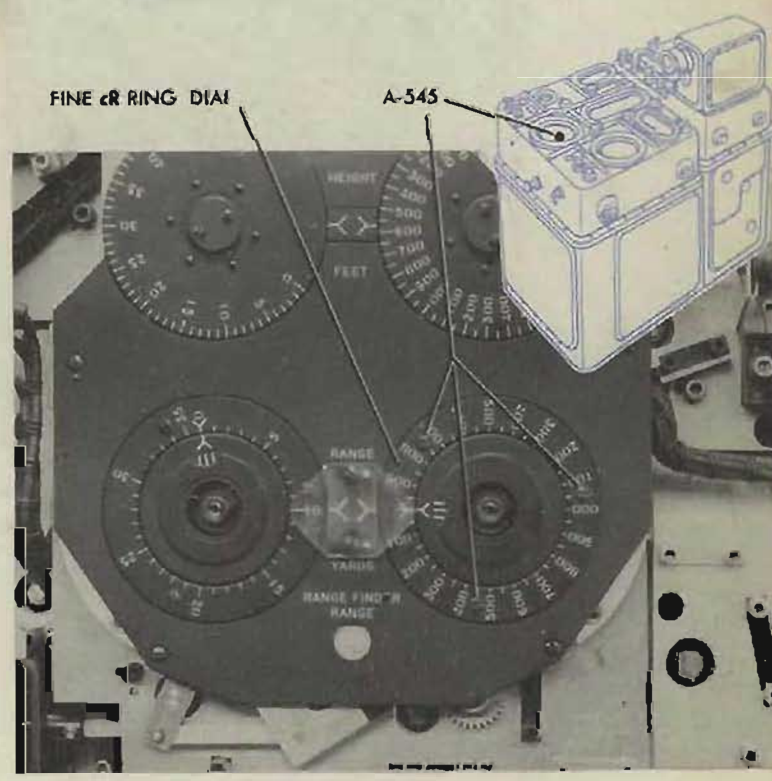
A-545 is under cover 1, on the fine *cR* ring dial.

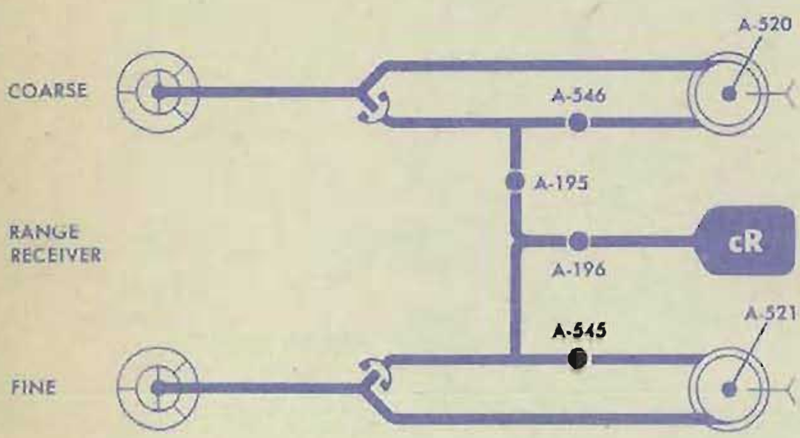
Check

Transmit 10,000 yards range from the director.
Keep the range finder's signal button depressed.
Turn the power ON.
Turn the range rate control switch to AUTO.
The index of the fine ring dial should match the index of the fine inner dial.

Adjustment

If the index of the fine *cR* ring dial does not match the index of the fine inner dial, loosen A-545 and slip the ring dial until the indexes match.

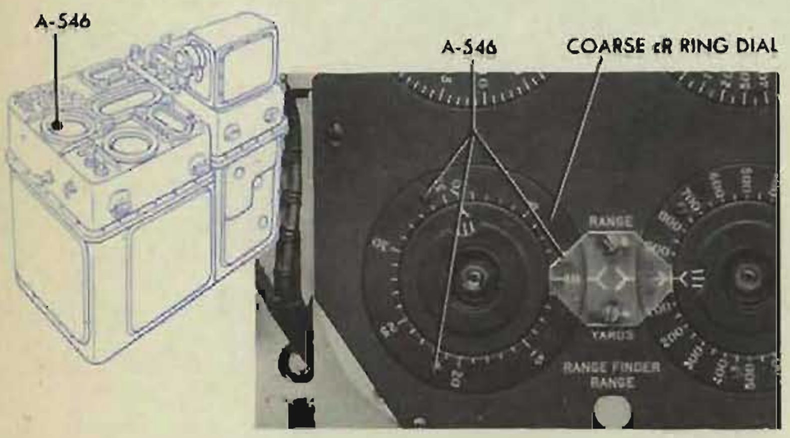




Tighten A-545 and recheck.

Check A-195 and A-521.

A-546 COARSE cR DIAL to FOLLOW-UP CONTACTS



Location

A-546 is under cover 1, on the coarse *cR* ring dial.

Check

Transmit 10,000 yards range from the director.

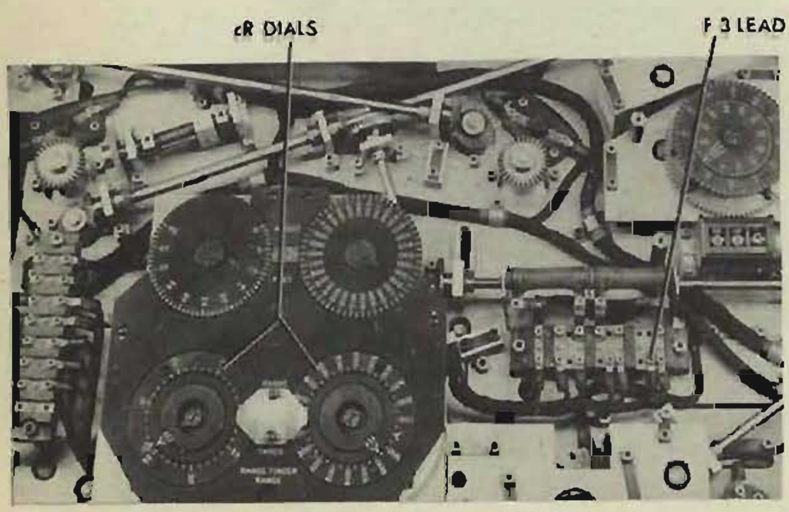
Keep the range finder's signal button depressed.
Turn the power ON.
Turn the range rate control switch to AUTO.

Disconnect the F3 fine control lead from the terminal block at the right of the *cR* dials.

Turn *cR* until the *jdR* follow-up opposes further travel. Read *cR*.

Turn *cR* in the opposite direction until the *jdR* follow-up opposes further travel. Again read *cR*.

With *cR* at the midpoint between the two readings, the index on the coarse ring dial should match the index on the coarse inner dial.



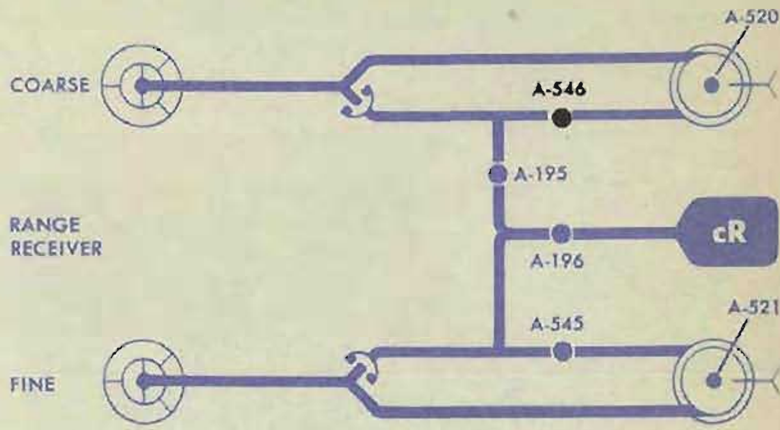
Adjustment

If the indexes do not match at the midpoint of the dead space, loosen A-546 and slip the ring dial until they do match.

Tighten A-546, and recheck.

Replace the F3 lead.

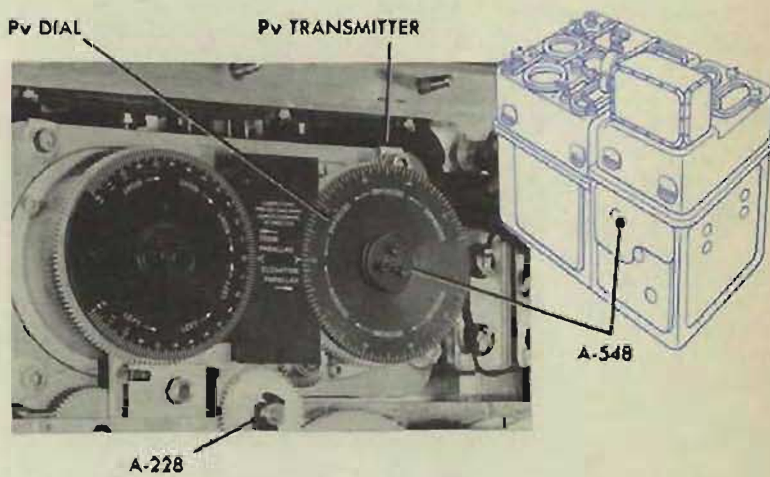
Check A-520 and A-195.



A-548 DIAL to SYNCHRO – Pv TRANSMITTER

Location

A-548 is under cover 6, on the dial of the *Pv* transmitter.
A-548 is omitted on Mods 0, 1, 2, 3, 4, 6, 9, and 10.

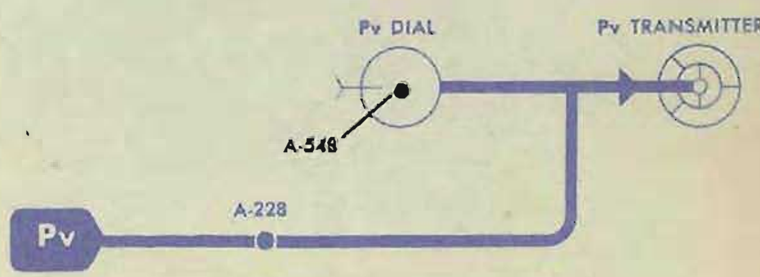


Check

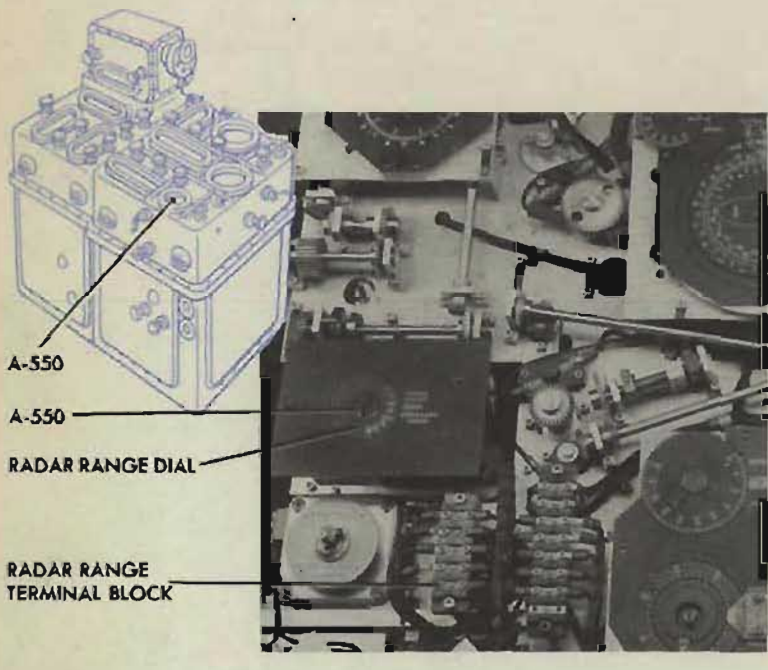
Loosen A-228 to disconnect the *Pv* line.
Set the synchro of the *Pv* transmitter on electrical zero.
The *Pv* dial should read 0°.

Adjustment

If the Pv dial does not read 0°, loosen A-548, and slip the dial to its proper reading.
Tighten A-548, and recheck.
Readjust A-228.



A-550 DIAL to SYNCHRO—RADAR RANGE RECEIVER



Location

A-550 is under cover 1, on the radar range dial.

Check

Connect a standard motor (test synchro) to the radar range receiver terminals. When the standard motor is on electrical zero, the radar range dial should read 10,000 yards.

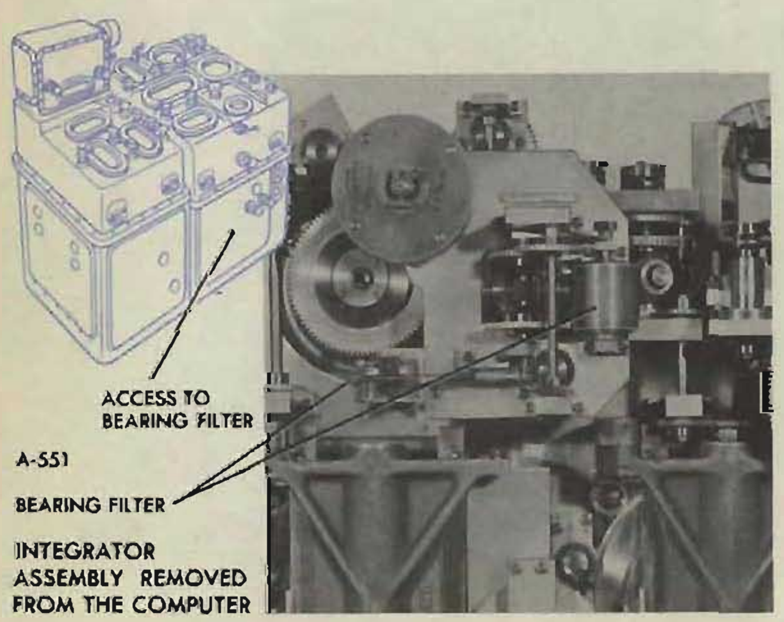
Adjustment

If the radar range dial does not read 10,000 yards when the receiver is on electrical zero, loosen A-550.
Hold the receiver on electrical zero, and slip the dial to its proper value.

Tighten A-550, and recheck.

Disconnect the standard motor from the terminals.

A-551 BEARING FILTER SPRING TENSION



Location

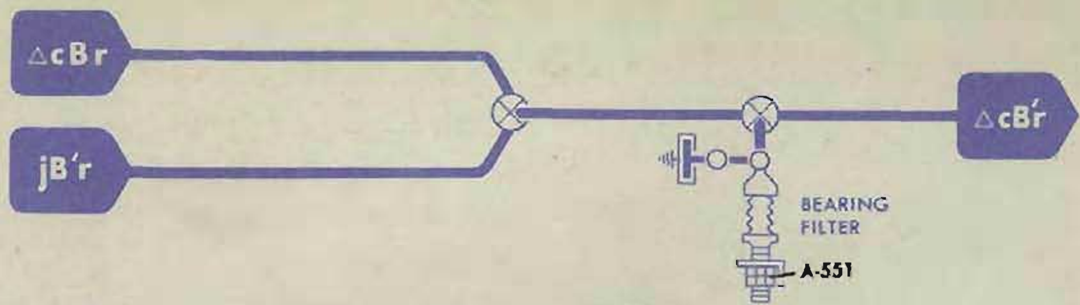
A-551 is under cover 3. It is a nut adjustment on the spring in the bearing filter.
It is omitted on Mod 0.

Check

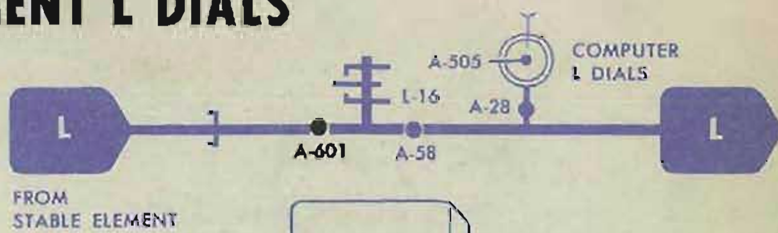
The spring supports should be 1.57 inches apart.

Adjustment

Loosen the locking nut. Turn the adjusting nut until the spring supports are the proper distance apart.
Tighten the locking nut.

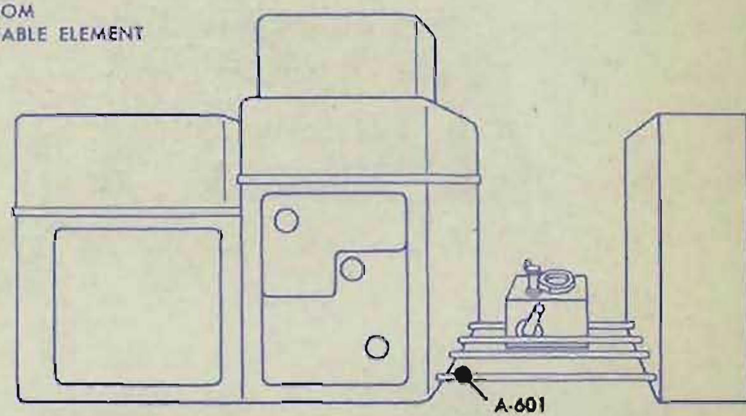


A-601 COMPUTER L DIALS to STABLE ELEMENT L DIALS



Location

A-601 is a clamp on the *L* shaft between the stable element and the computer.



Check

Set *L* at 2000′ at the stable element. The computer *L* dials should read 2000′.

Adjustment

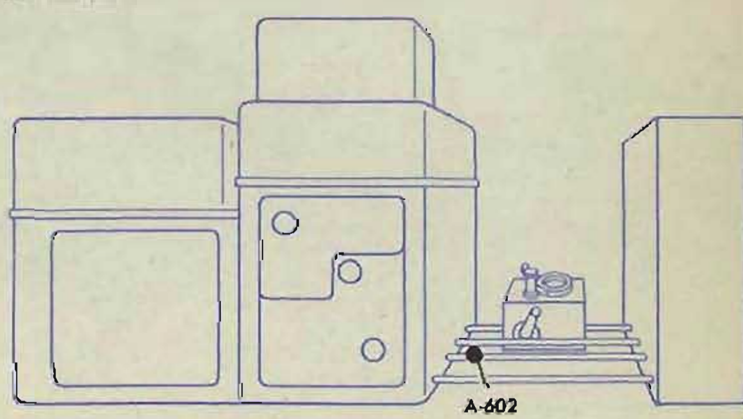
If the computer *L* dials do not read 2000′, loosen A-601 and turn the *L* stub shaft at the base of the computer until the computer and stable element dials agree.

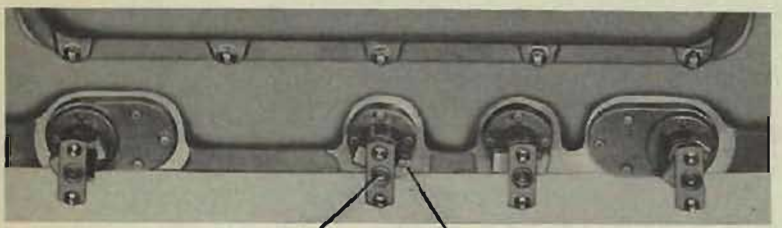
Tighten A-601, and recheck.

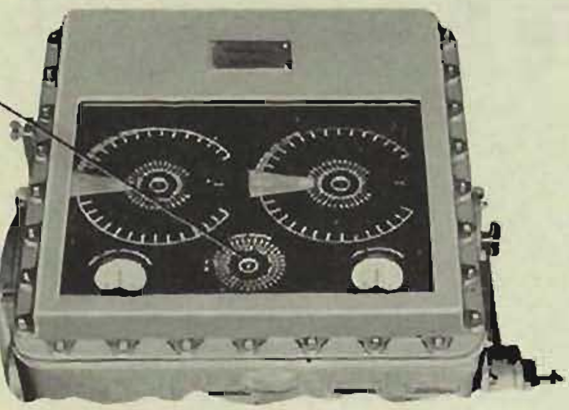
A-602 STABLE ELEMENT B′r DIALS to COMPUTER B′r LINE

Location

A-602 is a clamp on the *B′r* shaft between the computer and the stable element.







Check

Turn the power OFF.
Set *Dd* at 0°, and wedge the line.

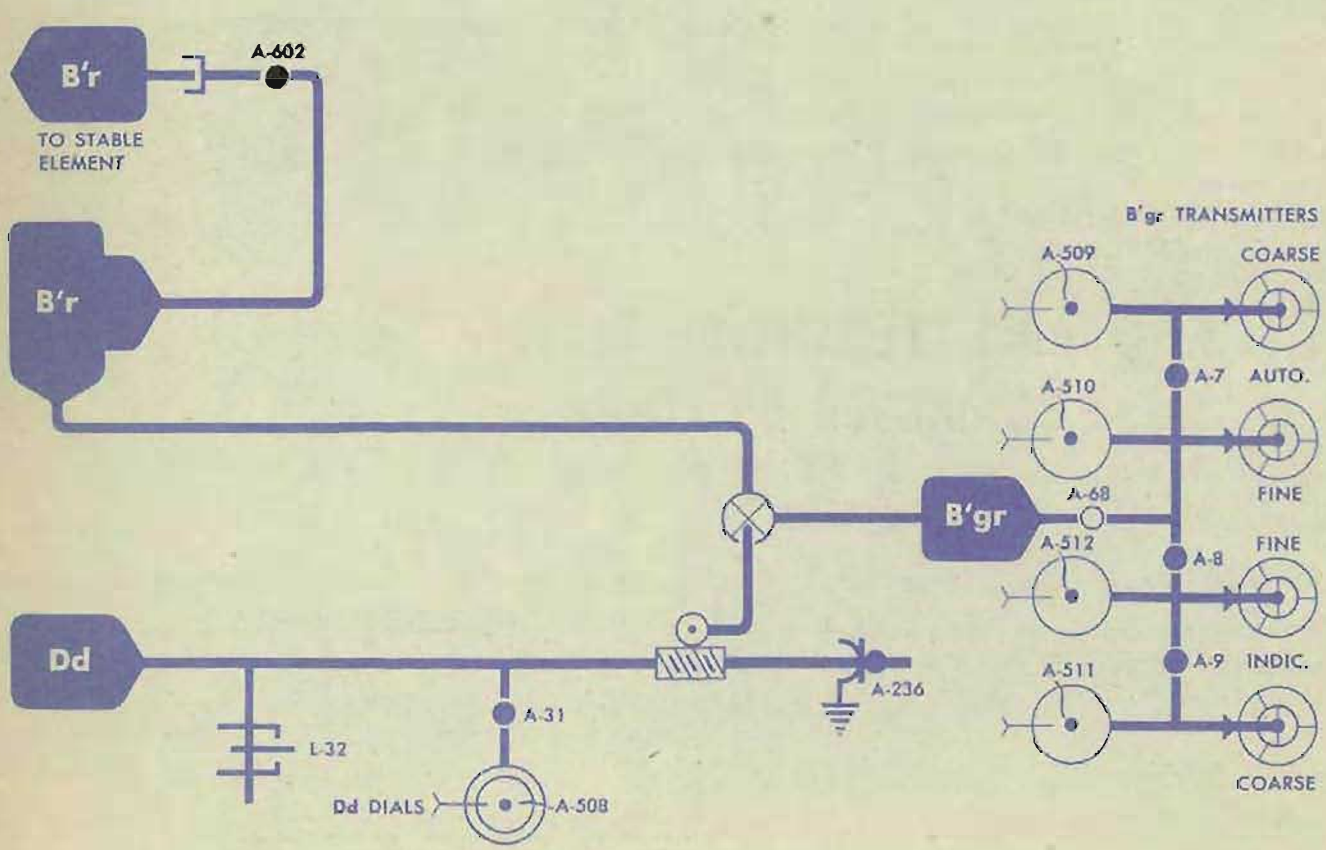
B'r now equals *B'gr*.

The reading on the stable element *B'r* dials should be the same as the reading on the computer *B'gr* dials.

Adjustment

If the stable element *B'r* dials do not agree with the computer *B'gr* dials, loosen A-602 and turn the *B'r* shaft at the base of the stable element until the dials agree.

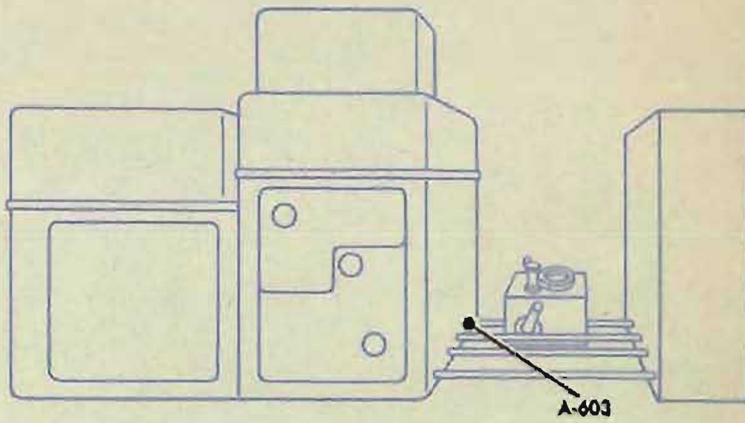
Tighten A-602, and recheck.



A-603 COMPUTER Zd DIALS to STABLE ELEMENT Zd DIALS

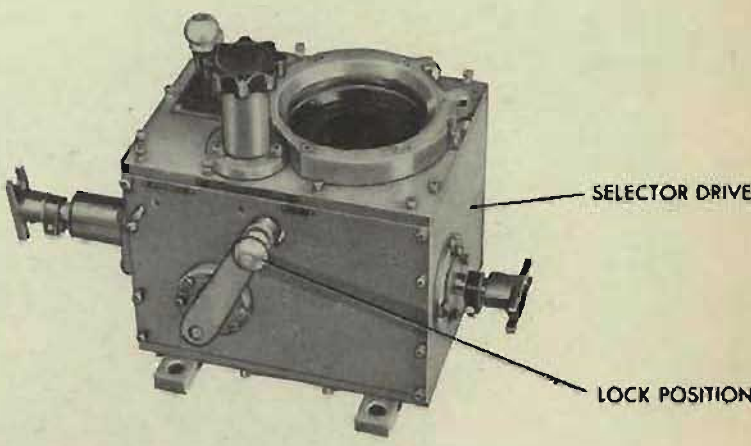
Location

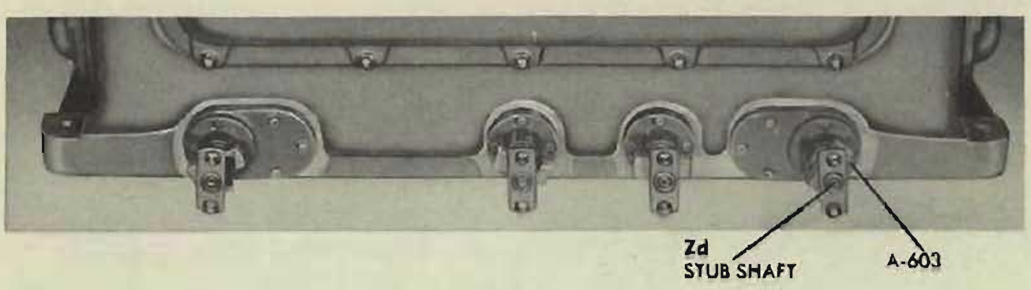
A-603 is a clamp on the *Zd* shaft between the computer and the stable element.



Check

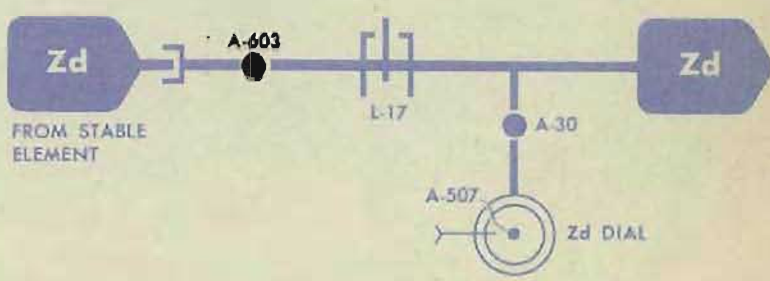
When the selector drive is in the LOCK position, the computer *Zd* dials should agree with the stable element *Zd* dials.





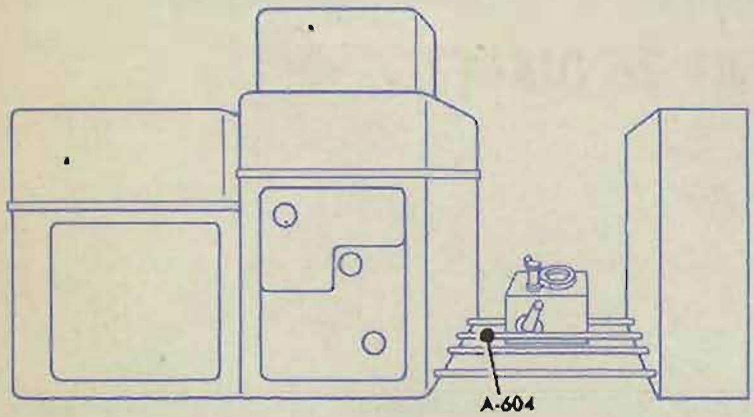
Adjustment

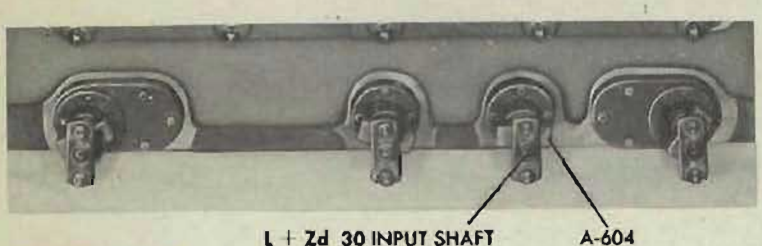
If the computer *Zd* dials do not agree with the stable element *Zd* dials, loosen A-603 and turn the *Zd* stub shaft at the base of the computer until the dials agree.



Tighten A-603, and recheck.

A-604 ASSEMBLY CLAMP





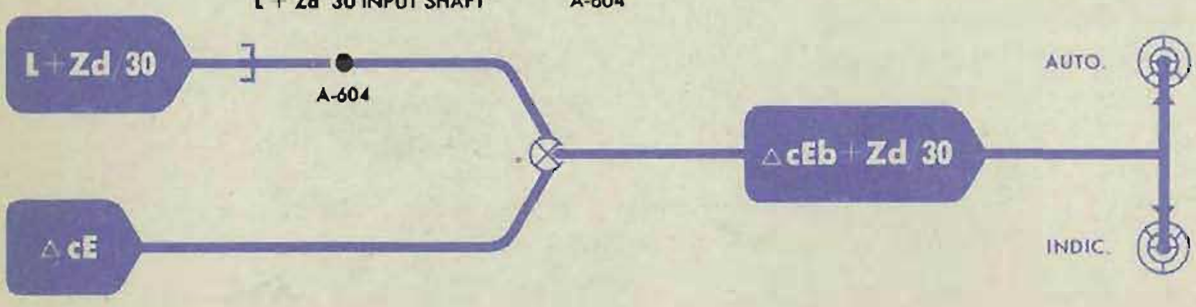
Location

A-604 is on the $L + Zd/30$ shaft, between the computer and the stable element.

Adjustment

No computer adjustment is necessary since the $L + Zd/30$ input is added only to the $\triangle cE$ integrator output.

The clamp must be tight.



A-607 I. V. DIAL to L-39

Location

A-607 is under cover 4, on the *I.V.* dial, on instruments with Ser. Nos. 811 and higher.

Check

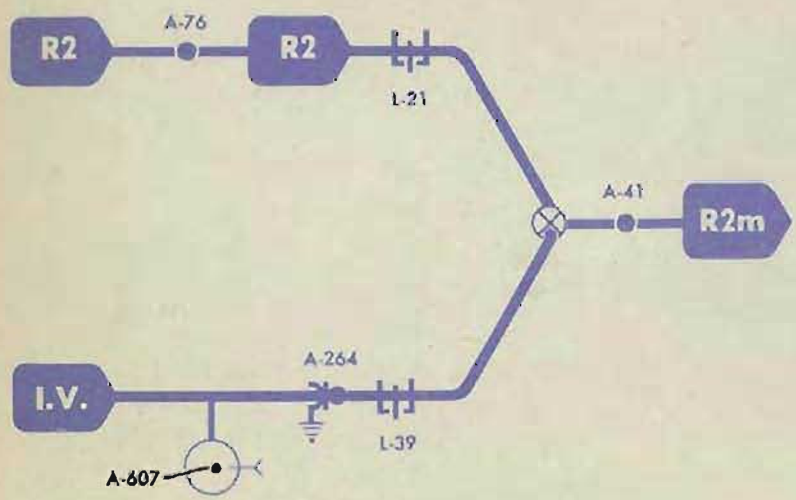
The front *I.V.* dial should read 2350 at the lower limit, and 2600 at the upper limit.

Adjustment

If the dial does not read the correct values, hold the line against the stop and loosen A-607. Slip the dial to the correct value.

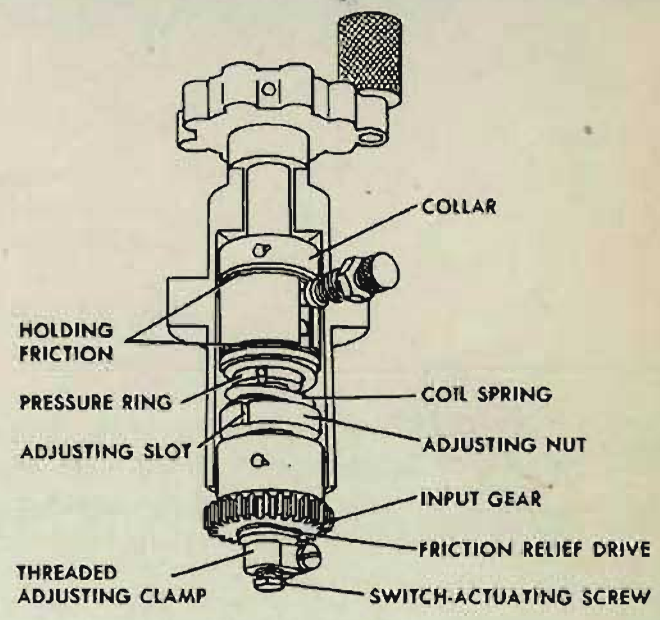
Tighten A-607 and check at the other limit.

Check A-76.



HANDCRANKS

The handcranks in the computer have various adjustable devices. These are the holding friction, the friction relief drive, and the switch-actuating screw.
Disassembly and repair of a typical handcrank is discussed in OP 1140A.



HOLDING FRICTION

Location

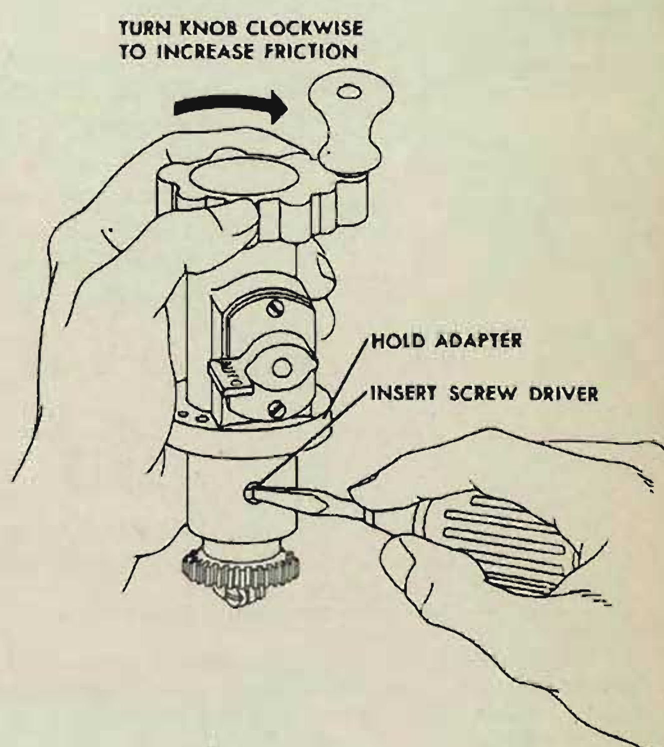
The holding friction is inside the handcrank.

Check

The holding friction should be tight enough to maintain the setting of its quantity under normal operating conditions, yet loose enough for easy operation.

Adjustment

Remove the handcrank from the cover and set it in the outer position. Turn the knob until the adjustment slot appears in the opening; then insert a small screw driver into the slot. Turn the knob clockwise to increase the friction, or counterclockwise to decrease the friction.



FRICTION RELIEF DRIVE

Location

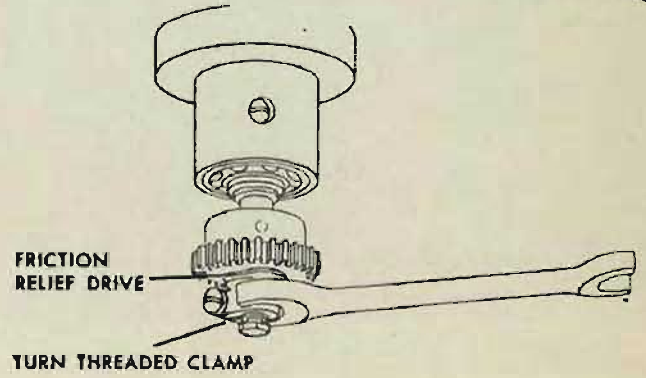
The friction relief drive is at the input gear on the end of the handcrank shaft.

Check

The friction relief drive should be tight enough to drive the line, but loose enough to slip without damaging the shaft line whenever a limit stop is reached.

Adjustment

Loosen the threaded adjustment clamp and turn it clockwise to increase the friction or counterclockwise to decrease the friction. Note that loosening the adjustment clamp also releases the switch-actuating screw. Therefore the screw adjustment should be checked whenever the drive friction is readjusted.



SWITCH-ACTUATING SCREW

Location

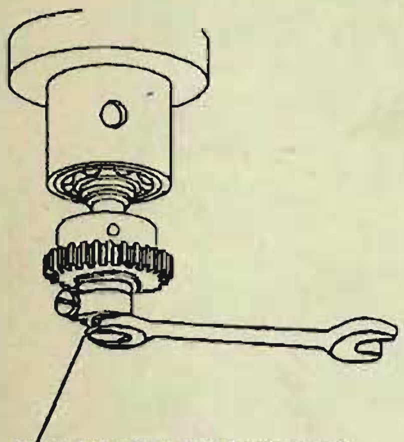
The switch-actuating screw is at the end of the handcrank shaft.

Check

The switch-actuating screw should extend far enough to depress the switch button when the handcrank is at IN or HAND. *It should not extend so far that it damages the switch.*

Adjustment

Loosen the friction relief drive adjustment clamp, but do not turn the clamp because that would change the adjustment of the drive friction. Use a wrench to turn the screw. The screw head must be smooth, because any burr on the surface will dig into the bakelite switch. Make sure that the adjustment clamp is tightened.


TURN SWITCH-ACTUATING SCREW

CAUTION

When reinstalling a handcrank which has a switch-actuating screw, make sure that the screw does not extend too far. To check this on a plunger-type handcrank, pull the plunger out and gently push the handcrank IN. Travel should be limited by the knob striking the adapter. On a lever-type handcrank, gently turn the switch lever to the HAND position. It should reach its limit stop pin with no restriction. In either type of handcrank, *if the travel is limited by the bottom of the switch, the screw extends too far and the switch will be damaged.*

TABLE

The following table indicates which handcranks have frictions, and which ones operate switches.

HANDCRANK	FRICTION DRIVE	HOLDING FRICTION	OPERATES SWITCH
Deflection Spot (*Dj*)	X	X	X
Elevation Spot (*Vj*)	X	X	X
Range Spot (*Rj*)	X	X	X
Fuze (*F*)	X	X	X
Sight Angle (*Vs*)	X	X	X
Sight Deflection (*Ds*)	X	X	X
Synchronize Elevation	X	Note A	Note B
Wind Speed (*Sw*)	X		
Ship Speed (*So*)	X	X	X
Target Speed (*Sh*)	X	X	X
Rate of Climb (*dH*)		X	

HANDCRANK	FRICTION DRIVE	HOLDING FRICTION	OPERATES SWITCH
Target Angle (*A*)		X	X
Ship Course (*Co*)		X	X
Wind Direction (*Bw*)			
Range Rate (*dR*)	X	X	X
Time (*T*)	X		
Generated Bearing (*jBr*)			
Generated Elevation (*jE*)	X		
Generated Range (*jR*)	X		
Dead Time (*Tg*)	X		
Initial Velocity (*I.V.*)	X		
Range Rate Ratio (*Rrr*)		X	

Note A: Holding friction to be such that handcrank in IN position rotates when either limit of L-12 is reached.
Note B: Switch to be open in OUT position, and closed in CENTER and IN positions.

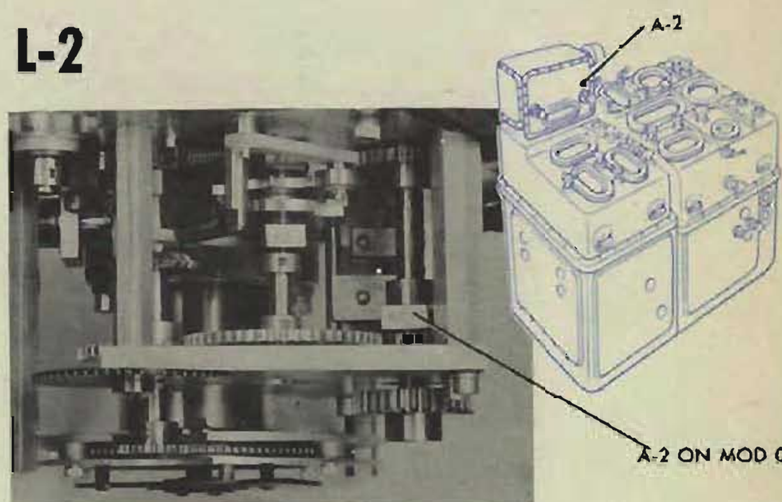
STAR SHELL READJUSTMENT

A-1 ASSEMBLY CLAMP (see A-18)

A-2 Rjn RING DIAL to L-2

Location

A-2 is under the front cover, behind the *Rjn* input.



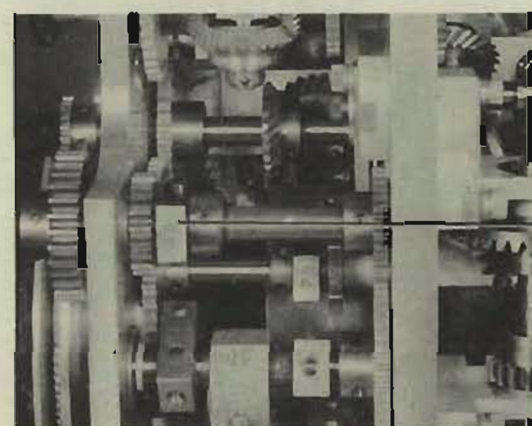
Check

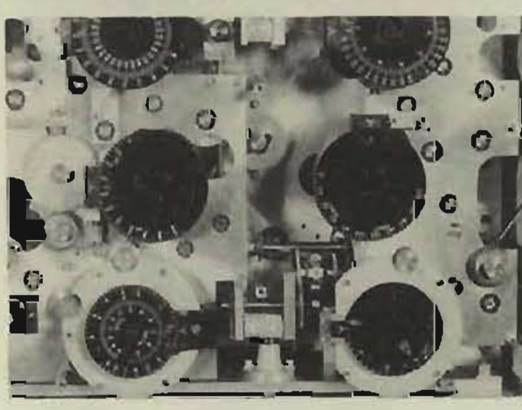
L-2 should function at:

IN 1500 yards and OUT 1500 yards, on Mod 0.
IN 2857 yards and OUT 1500 yards, on Mod 1.
IN 2700 yards and OUT 1500 yards, on Mod 2.

NOTE: On Mods 1 and 2, the IN limit is indicated by a red dot beyond the IN 1500-yard graduation.

Turn the *Rjn* input in an increasing direction until the limit of the stop is reached. The *Rjn* ring dial should read 1500 yards OUT.

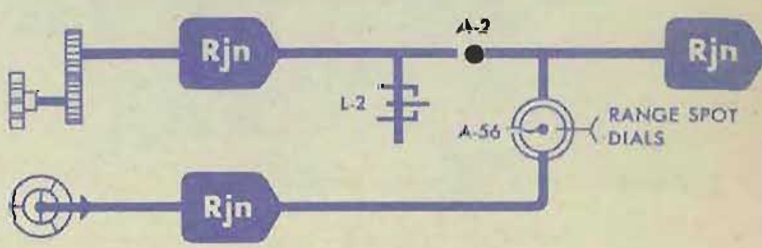




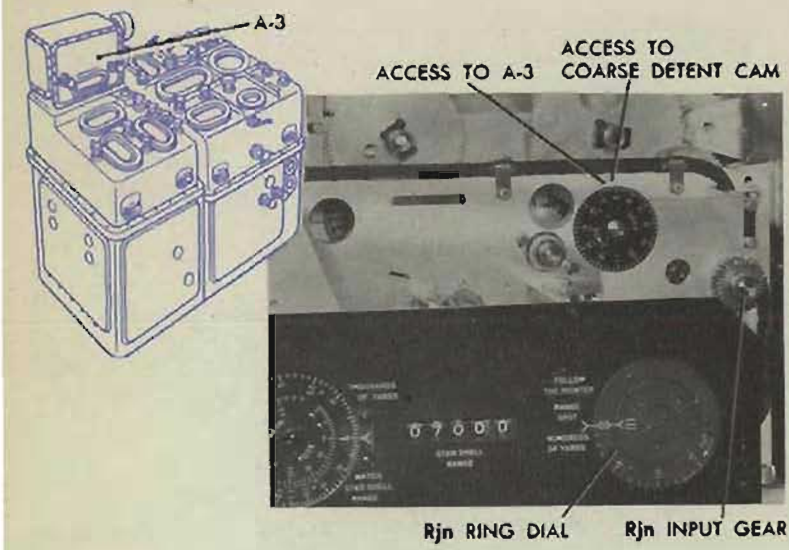
Adjustment

Loosen A-2.
Hold the *Rjn* input gear against the upper limit of the stop. Turn the spur gear in front of A-2 until the ring dial reading is correct.

Tighten A-2 and recheck at the IN limit.

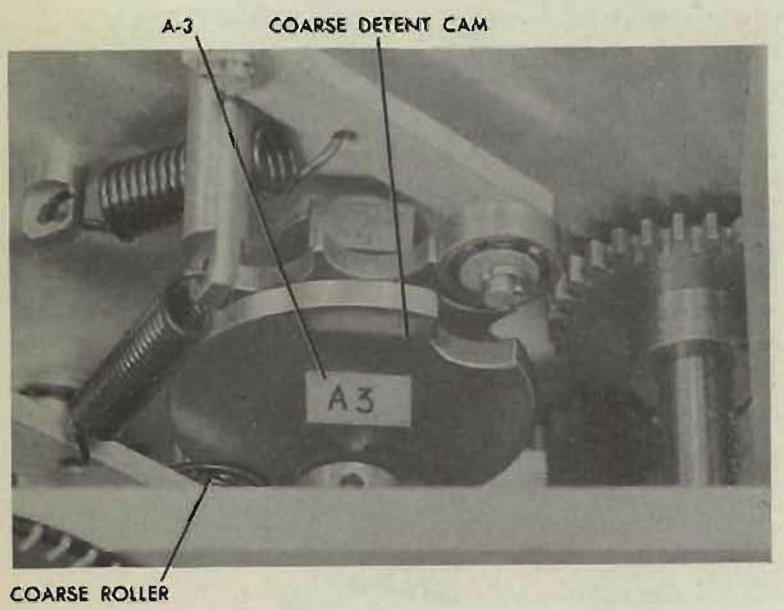


A-3 COARSE DETENT to Rjn RING DIAL



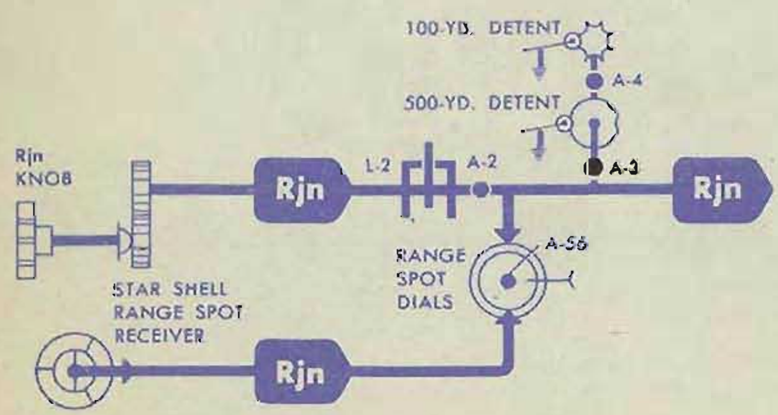
Location

A-3 is under the front cover, on the coarse detent cam, behind the *Rjn* input. A-3 is omitted on Mods 1 and 2.



Check

Set the *Rjn* ring dial at 0. Use the *Rjn* input gear.
The coarse detent roller should be in a notch of the coarse cam.



Adjustment

If the coarse detent roller is not in a notch on the coarse cam, loosen A-3. Turn the cam until the detent roller enters either notch.

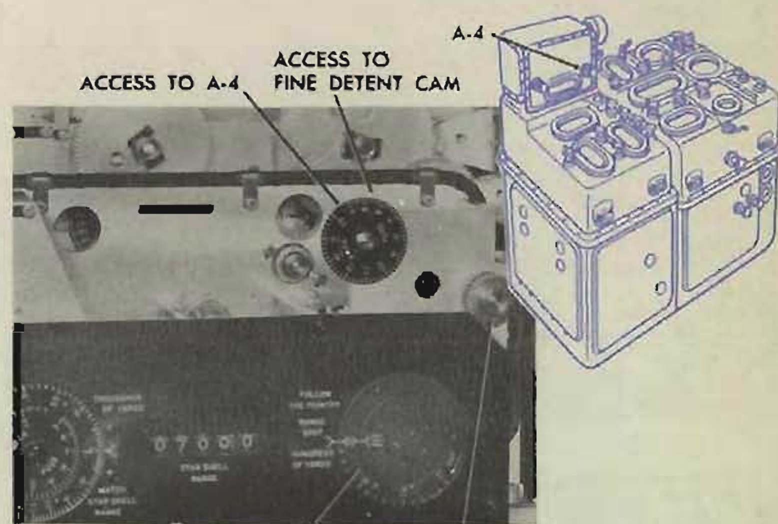
Tighten A-3 and recheck.

The detent should act at every 500-yard setting of the *Rjn* ring dial.

A-4 FINE DETENT to Rjn RING DIAL

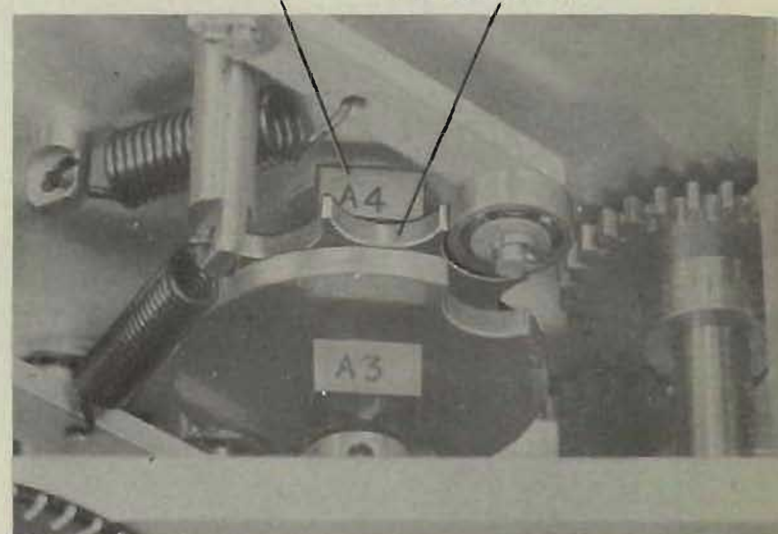
Location

A-4 is under the front cover, on the fine detent cam, behind the *Rjn* input.



Check

Set the *Rjn* ring dial at 0. Use the *Rjn* input gear.
The fine detent roller should be in a notch of the fine cam.

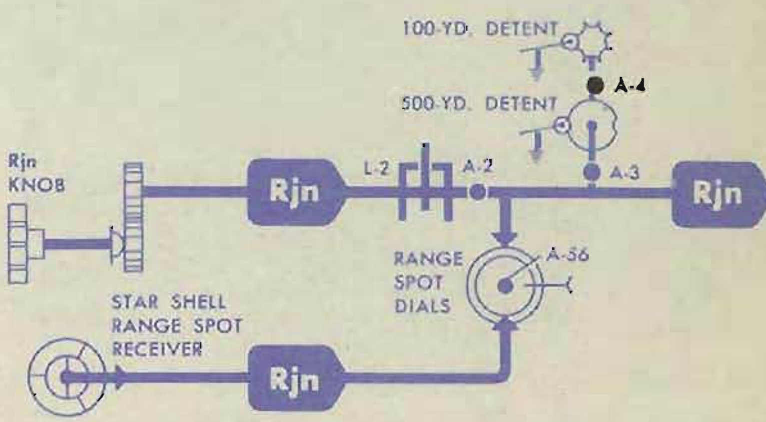


Adjustment

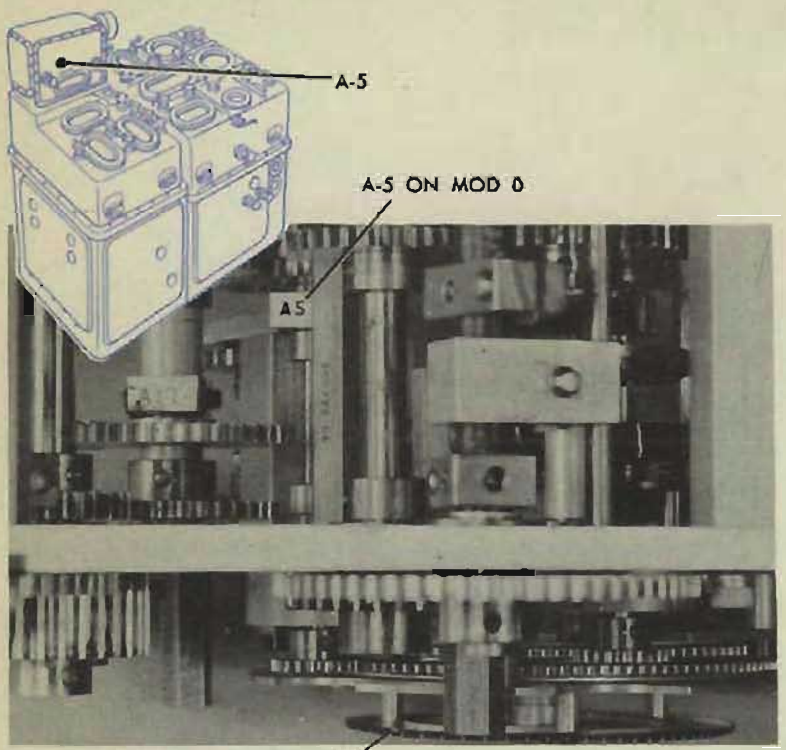
If the fine detent roller is not in a notch of the fine cam, loosen A-4. Turn the cam until the detent roller enters a notch.

Tighten A-4 and recheck.

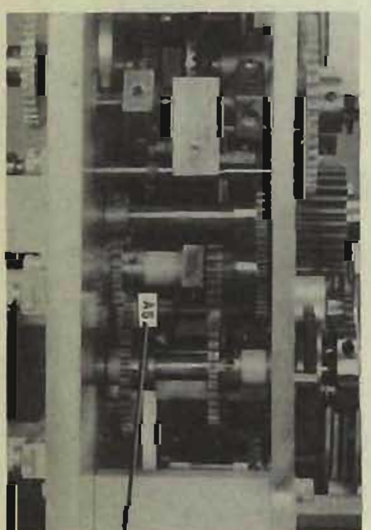
The detent should act at every 100-yard setting of the *Rjn* ring dial.



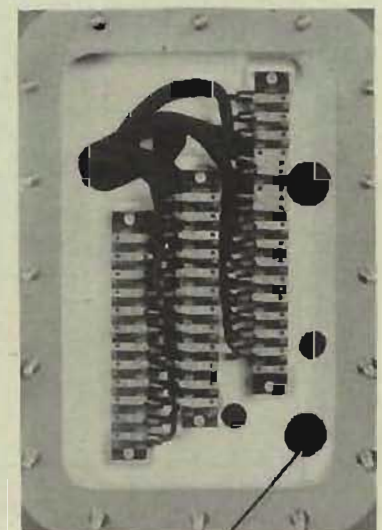
A-5 STAR SHELL RANGE RING DIAL to L-4



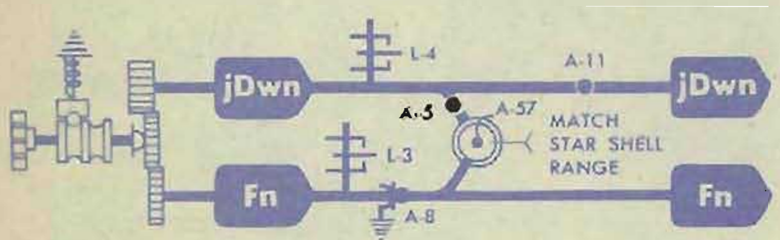
STAR SHELL RANGE RING DIAL



A-5 ON MODS 1 AND 2



ACCESS TO A-5 ON MODS 1 AND 2



Location

A-5 is under the front cover. On Mods 1 and 2, A-5 can be reached through an access hole under the junction box cover.

Check

On Mods 0 and 1, L-4 should operate at 4,000 and 15,000 yards on the *jDwn* ring dial. On Mod 2 it should operate at 8,000 and 19,500 yards.

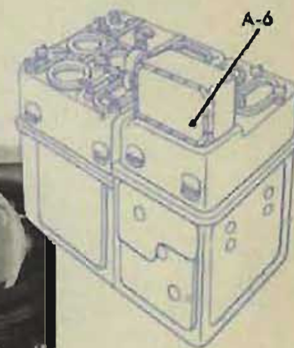
Decrease star shell range to the lower limit of the stop. The *jDwn* ring dial should read 4,000 yards (8,000 yards on Mod 2).

Adjustment

If the *jDwn* ring dial does not read 4,000 yards (8,000 on Mod 2), loosen A-5. Hold the *jDwn* line against the stop and turn the small spur gear at the left of the ring dial until the dial reading is correct.

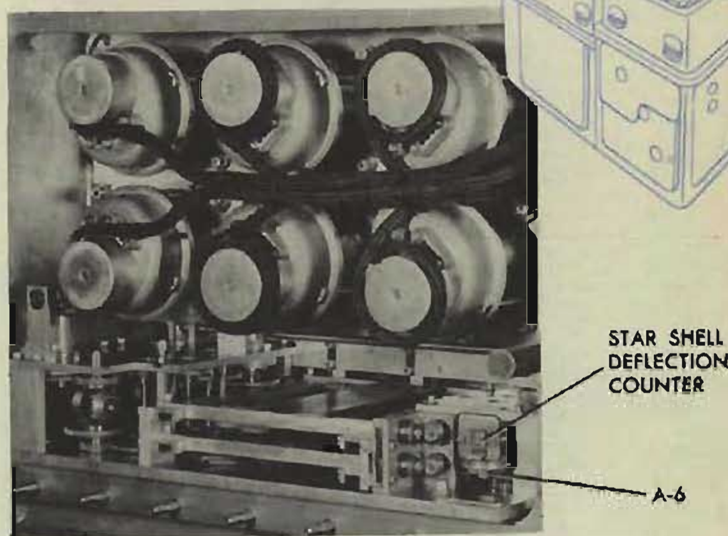
Tighten A-5, and check at the upper limit. Check A-11 in the star shell computer and A-231 in the Computer Mark 1.

A-6 STAR SHELL DEFLECTION COUNTER to L-1



Location

A-6 is under the rear cover, below the star shell deflection counter.

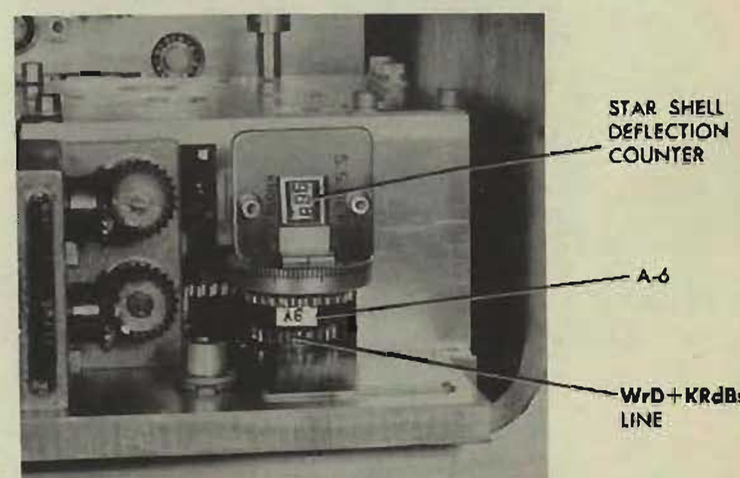


Check

L-1 should operate at +60 knots (counter reading 060) and −60 knots (counter reading 940).

Turn the power OFF.

Run the *WrD* + *KRdBs* line to the upper end of the limit stop by turning the spur gear under clamp A-6. The star shell deflection counter should read 060.



Adjustment

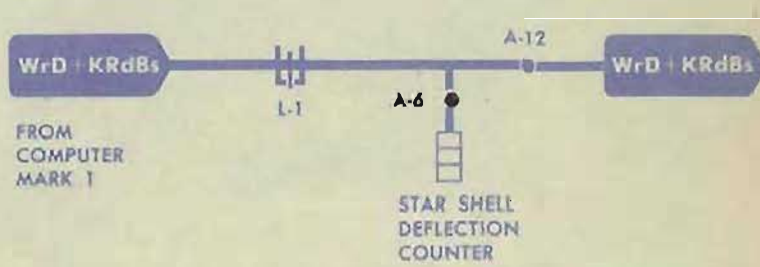
If the counter does not read 060, slip-tighten A-6. Turn the counter gearing until the counter reading is correct.

Tighten A-6, and recheck at the lower limit. Split any overtravel.

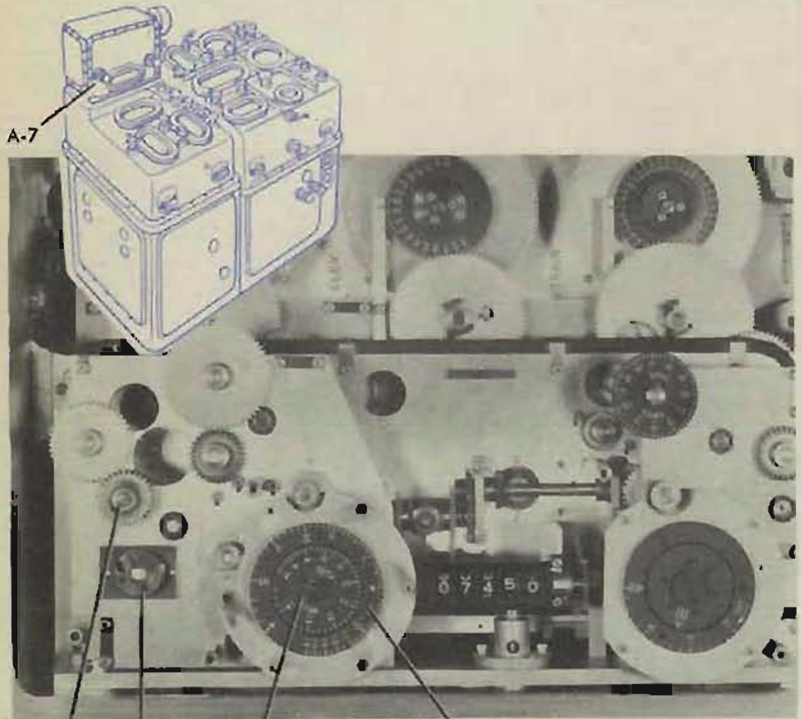
Note

If a long graduation on the drum does not line up with the index when the counter digits are centered, loosen the small clamp on the counter shaft, and align the drum with the counter. Recheck A-6.

Check A-12 in the star shell computer and A-230 in the Computer Mark 1.



A-7 jDwn HOLDING FRICTION



Location

A-7 is under the front cover, below the *jDwn* input gear.

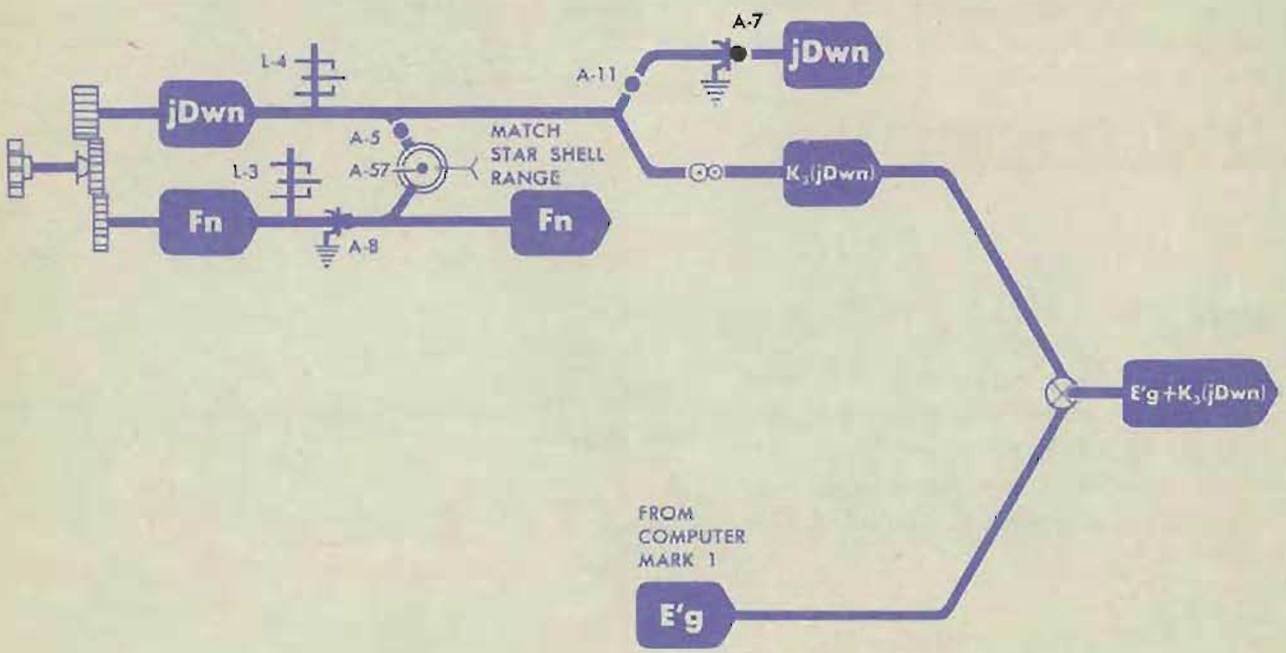
Check

A-7 should hold the *jDwn* setting without too much drag on the line. Increase and decrease *E'g* rapidly. There should be no movement of the *jDwn* range dial.

Adjustment

If *E'g* backs out the *jDwn* line and moves the dial, loosen A-7. Turn the clamp clockwise to increase the friction.

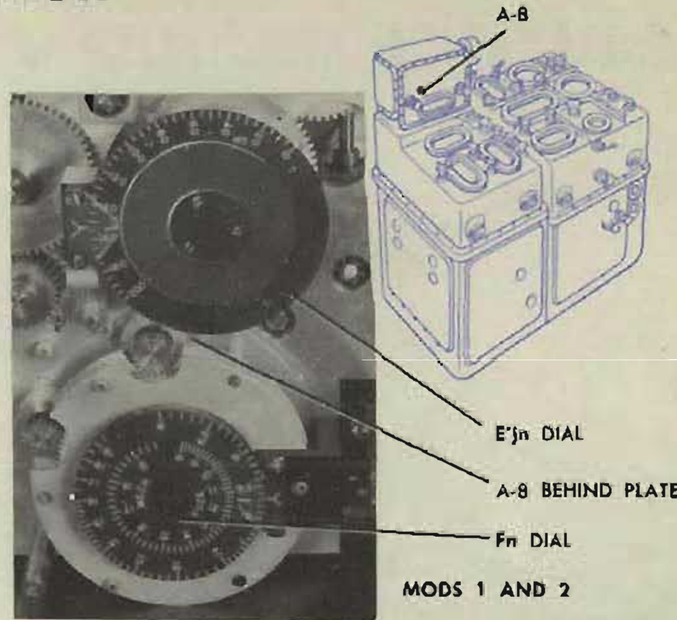
Tighten A-7, and recheck.



A-8 Fn HOLDING FRICTION

Location

A-8 is under the front cover.



MODS 1 AND 2

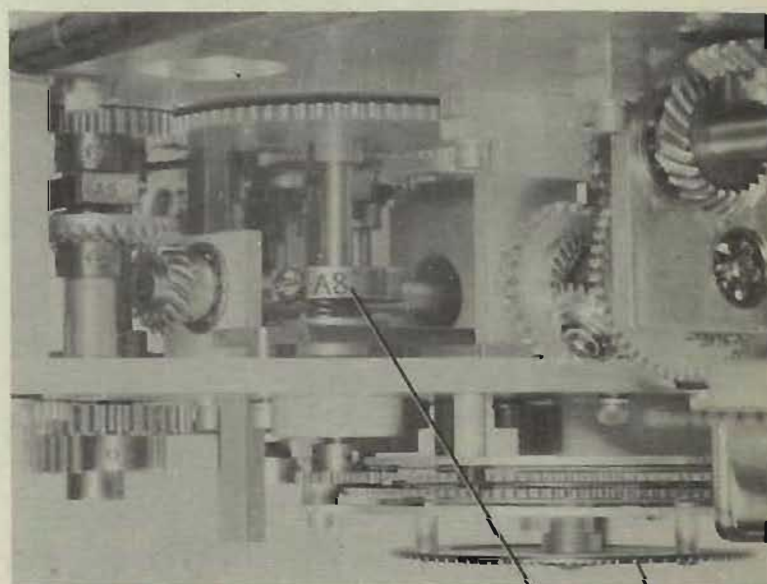
Check

A-8 should hold the *Fn* setting without too much drag on the line.

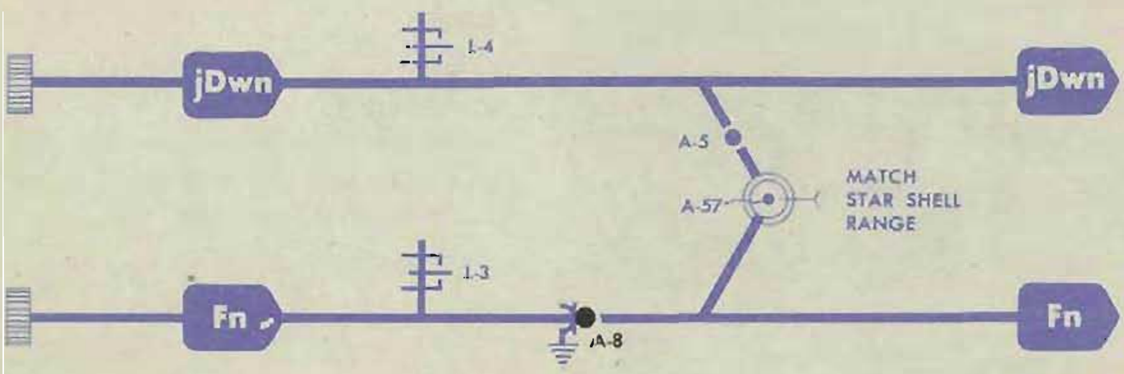
Adjustment

If the *Fn* setting moves off as the transmitters are energized, loosen A-8. Turn the clamp clockwise to increase the friction.

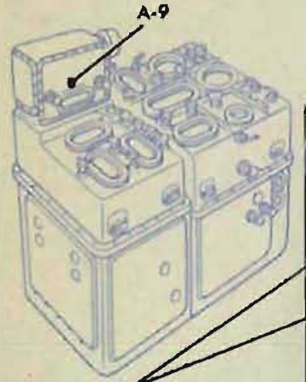
Tighten A-8, and recheck.

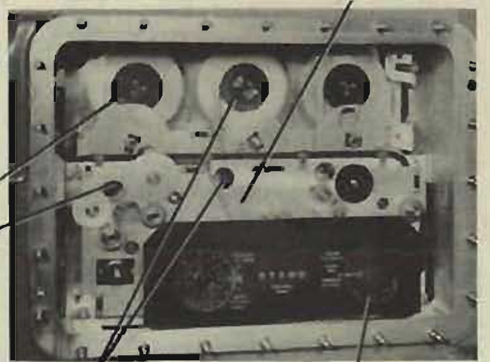


MOD 0



A-9 ELEVATION MULTIPLIER to Fn DIALS



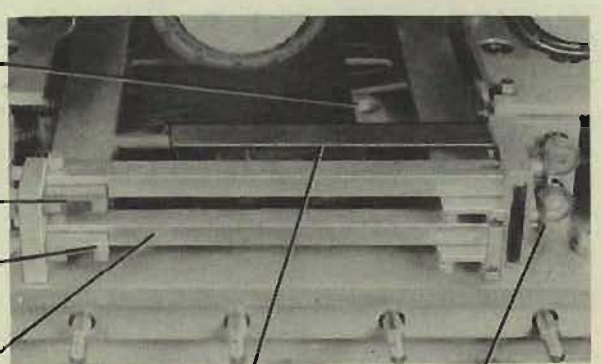


Location

A-9 is under the front cover. On Mods 1 and 2, A-9 is reached through an access hole at the side.

Check

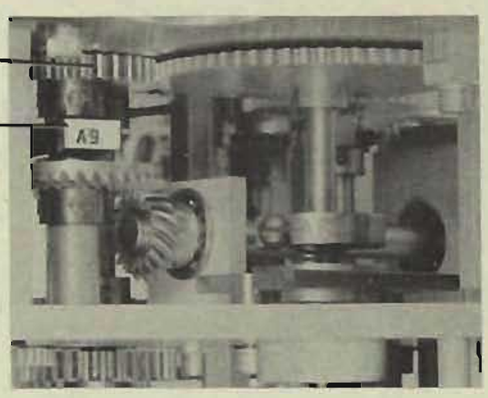
Set *Fn* at 20.85 seconds.
The edge of the elevation multiplier slide block should be exactly 2½ inches from the end of the multiplier.



Adjustment

If the block is not 2½ inches from the end of the multiplier, slip-tighten A-9.
Wedge *Fn* at 20.85 seconds.
Turn the small bevel gear on the lead screw of the multiplier until the slide block is positioned correctly.
Tighten A-9, and recheck.
Remove the wedge.

A-9 ALTERNATE METHOD of readjusting

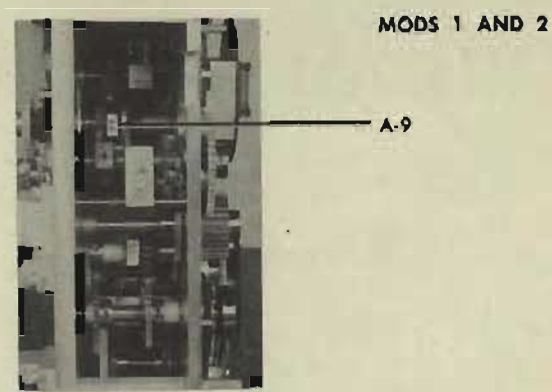


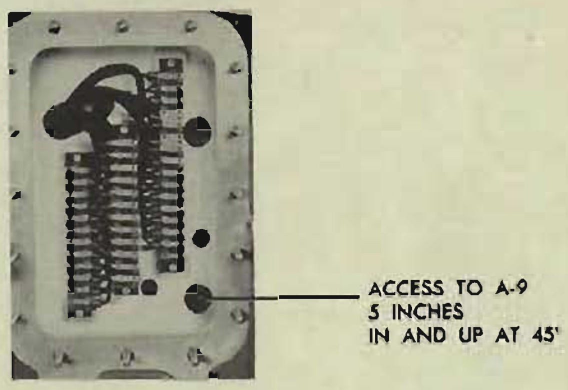
Check

Wedge the *E'g* line from the Computer Mark 1.
Wedge the *jDwn* input line.
On Mods 1 and 2, wedge the *E'jn* line.
Set *Fn* at 35.00 seconds.

Gene Slover's US Navy Pages
Table of Contents

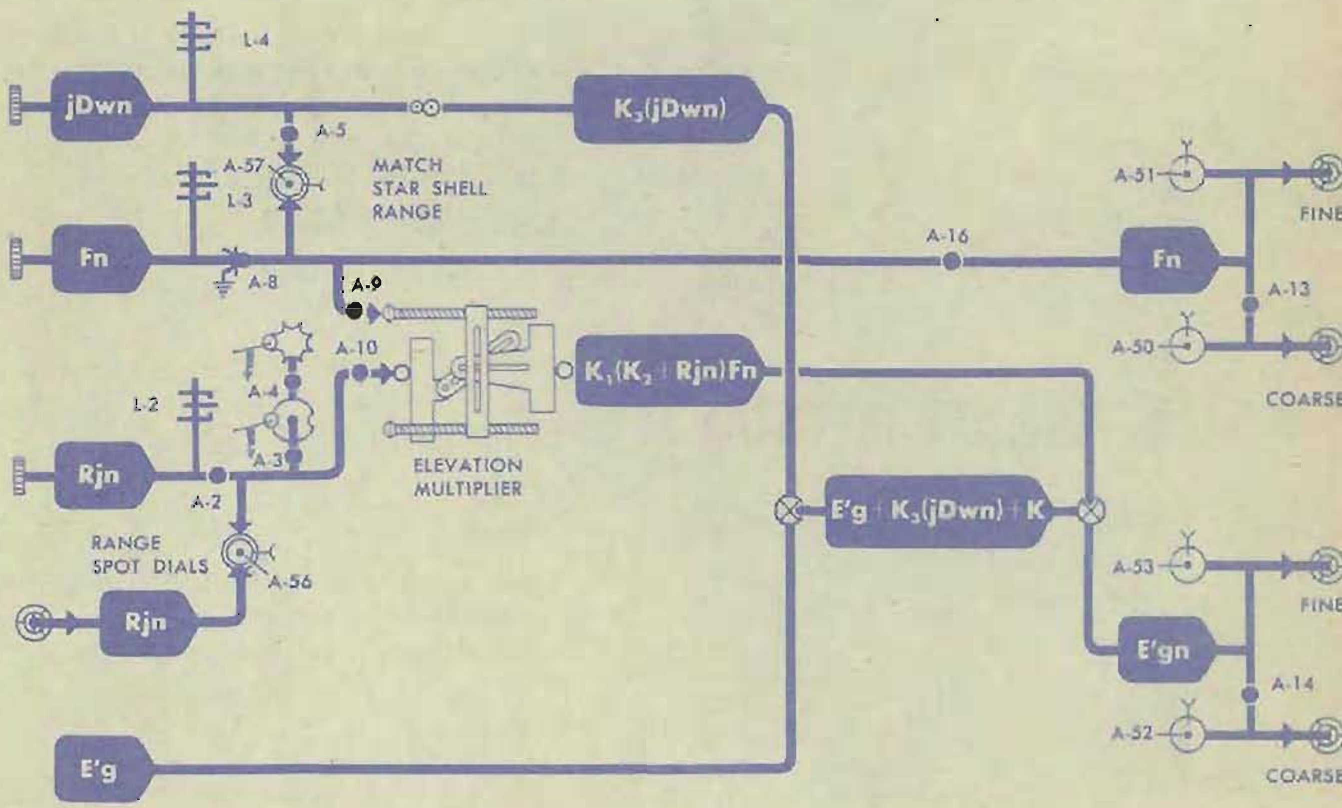
Set the *Rjn* ring dial at IN 1400 yards.
Read the *E'gn* dials (*E'gjn* dials on Mods 1 and 2).
The input screw of the elevation multiplier should be positioned so that increasing *Rjn* to OUT 1400 yards causes *E'gn* (or *E'gjn*) to increase 393.4′ on Mods 0 and 1, or 315.5′ on Mod 2.





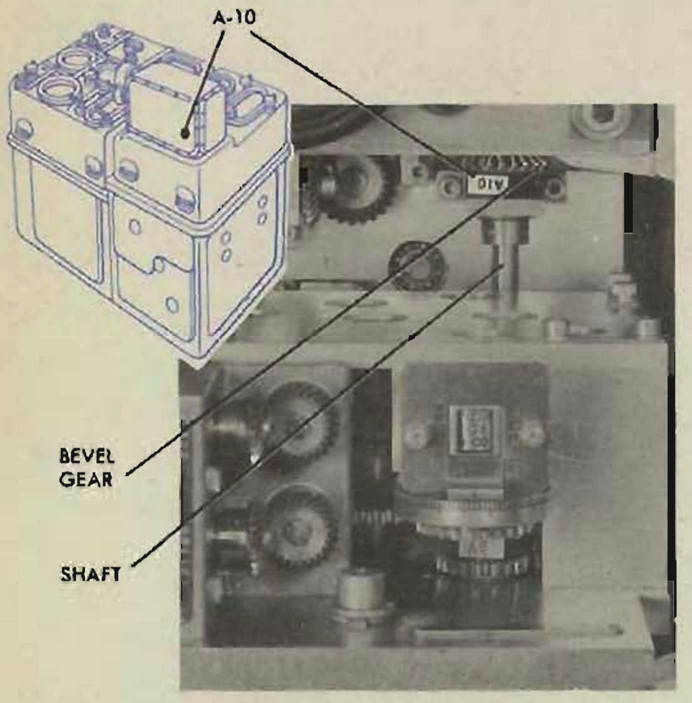
Adjustment

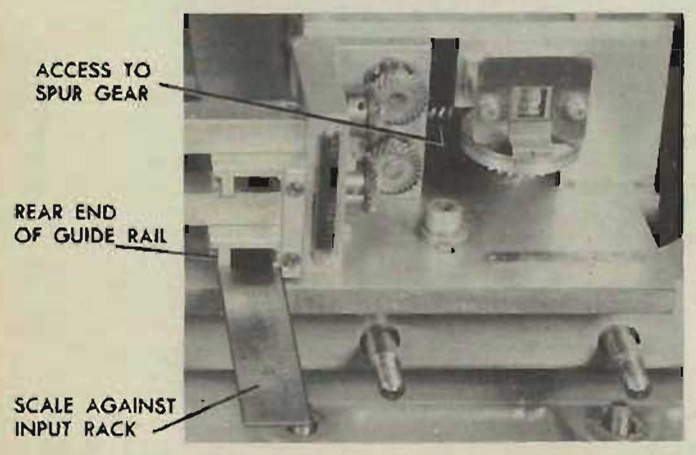
If *E'gn* (or *E'gjn*) does not increase the correct amount, slip-tighten A-9. Turn the spur gear at the rear of A-9 until the change in *E'gn* (or *E'gjn*) is correct.
Tighten A-9, and recheck.
Remove the wedges from the *E'g*, *E'jn*, and *jDwn* lines.
Check A-231 in Computer Mark 1.



MOD 0

A-10 ELEVATION MULTIPLIER to Rjn RING DIAL





Location

A-10 is under the back cover, above and in front of the star shell deflection counter.

Check

Set the *Rjn* dial at IN 200 yards. The multiplier input rack should be exactly 2½ inches from the rear end of the guide rail.

Adjustment

If the rack is not exactly 2½ inches from the end of the guide rail, slip-tighten A-10.

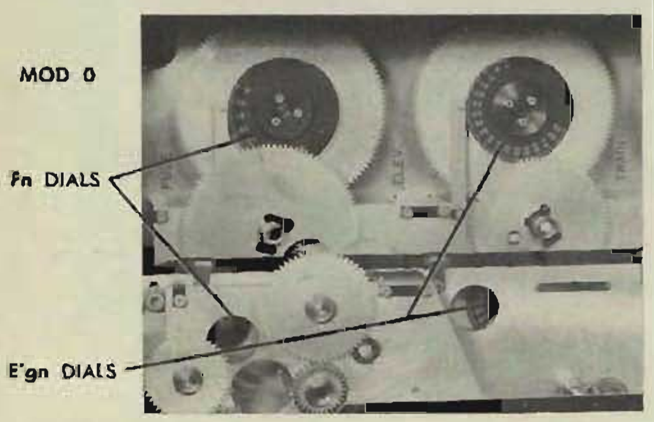
Wedge the *Rjn* line at IN 200 yards.

Turn the spur gear which meshes with the input rack until the rack is 2½ inches from the end of the guide rail.

Tighten A-10, and recheck.

Remove the wedge.

A-10 ALTERNATE METHOD of readjusting



Check

Wedge the *E'g* line from the Computer Mark 1.

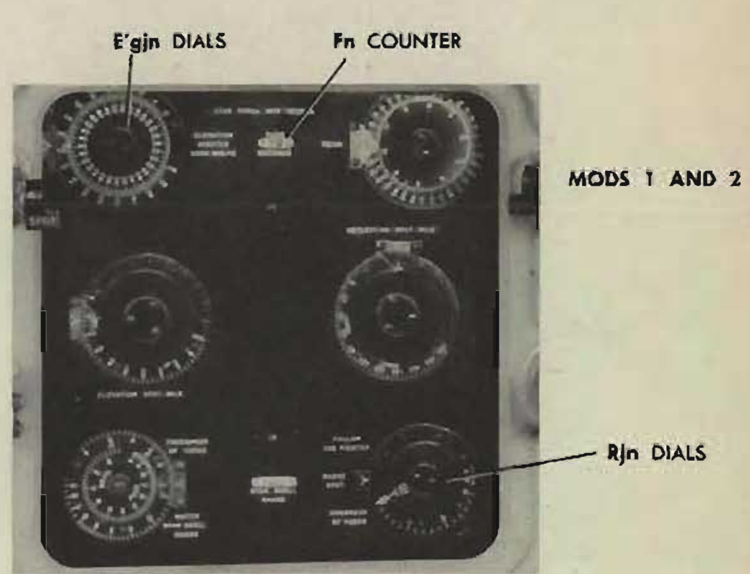
On Mods 1 and 2, wedge the *E'jn* line.

Wedge the *jDwn* input line.

Set the *Rjn* ring dial at OUT 1,000 yards. Use the *Rjn* input gear.

Set *Fn* at 10.00 seconds. Use the *Fn* input gear.

Read the *E'gn* dials (*E'gjn* dials on Mods 1 and 2). Increase *Fn* to 30.00 seconds.
The *E'gn* (or *E'gjn*) dial reading should have increased 309.6' on Mods 0 and 1, or 203.3' on Mod 2.

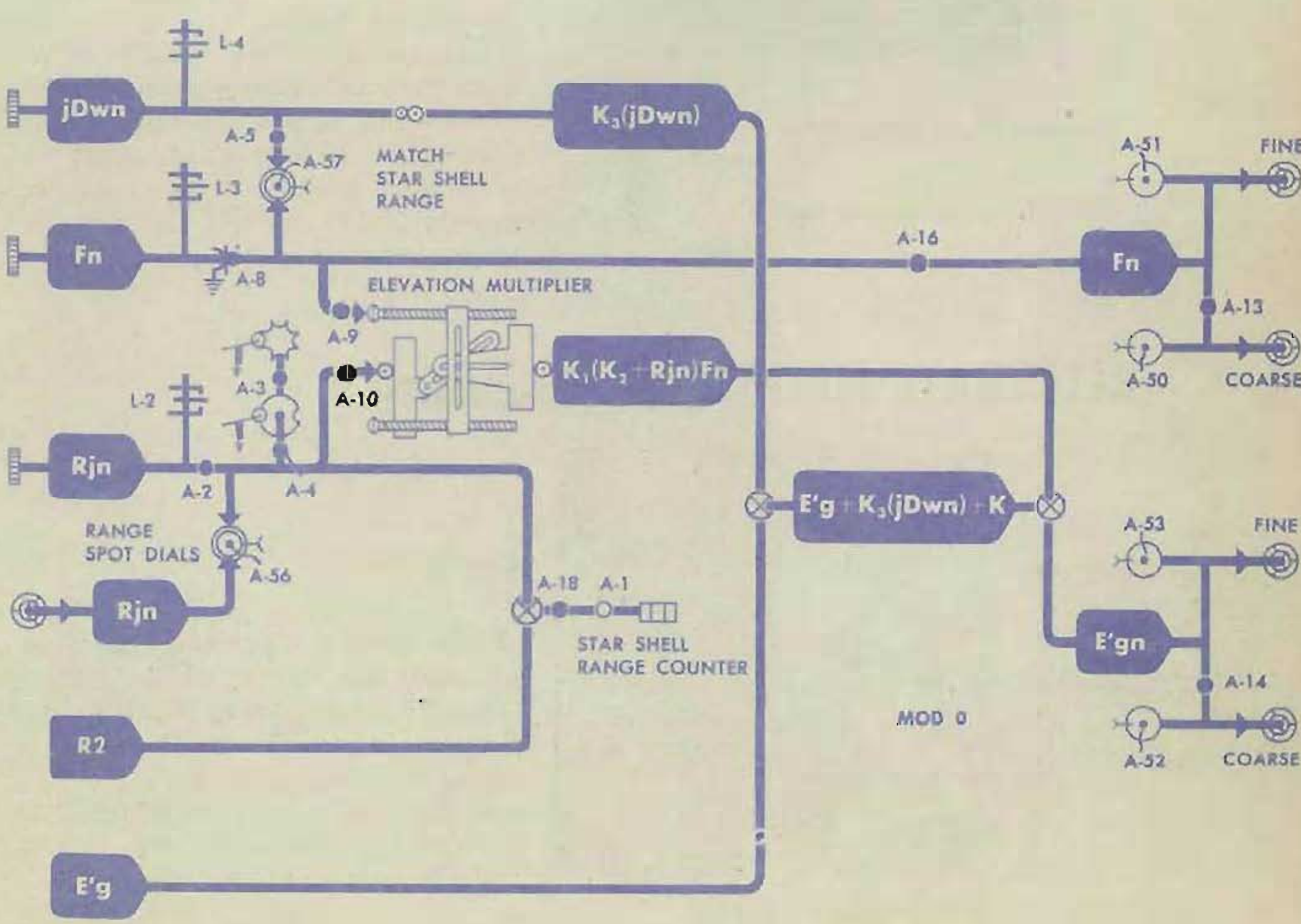


Adjustment

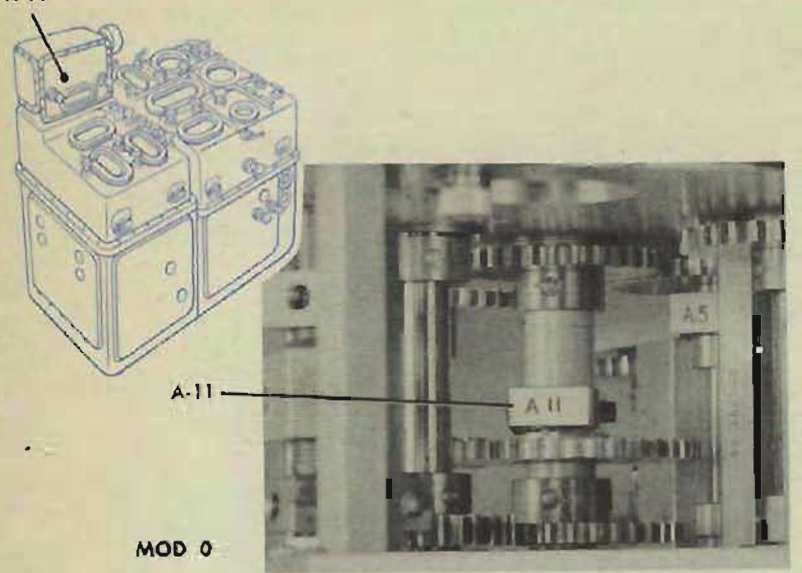
If *E'gn* (or *E'gjn*) does not increase the proper amount, slip-tighten A-10. Hold the bevel gear and turn the shaft below A-10 until the change in *E'gn* (or *E'gjn*) is correct.

Tighten A-10, and recheck.

Remove the wedges on the *E'g*, *E'jn*, and *jDwn* lines.
Check A-231 in Computer Mark 1.



A-11 DEFLECTION MULTIPLIER to *jDwn* LINE

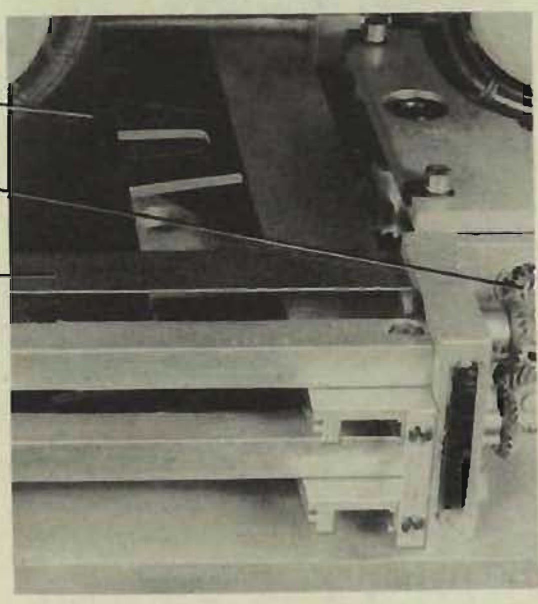


Location

A-11 is under the front cover, on the *jDwn* line. On Mods 1 and 2, A-11 can be reached through an access hole under the junction box cover.

Check

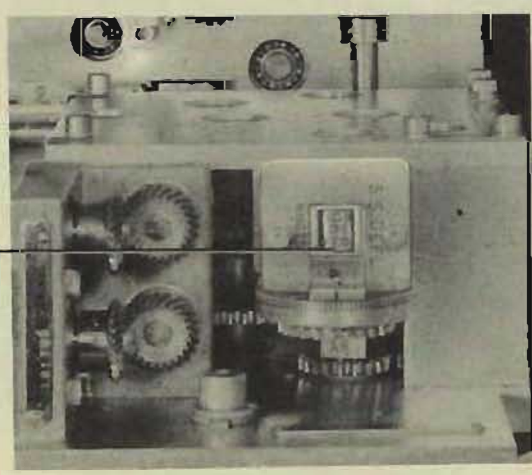
Set the *jDwn* ring dial at 8,000 yards. On Mods 0 and 1, the slide block on the deflection multiplier should be exactly 2½ inches from the end of the multiplier. On Mod 2, it should be ½ inch from the end of the multiplier.



Adjustment

If the block is not correctly positioned in relation to the end of the guide rail, slip-tighten A-11.
Wedge the *jDwn* line at 8,000 yards.
Turn the small bevel gear on the lead-screw input of the deflection multiplier until the block is the correct distance from the end of the multiplier.
Tighten A-11, and recheck.
Remove the wedge.
Check A-17.

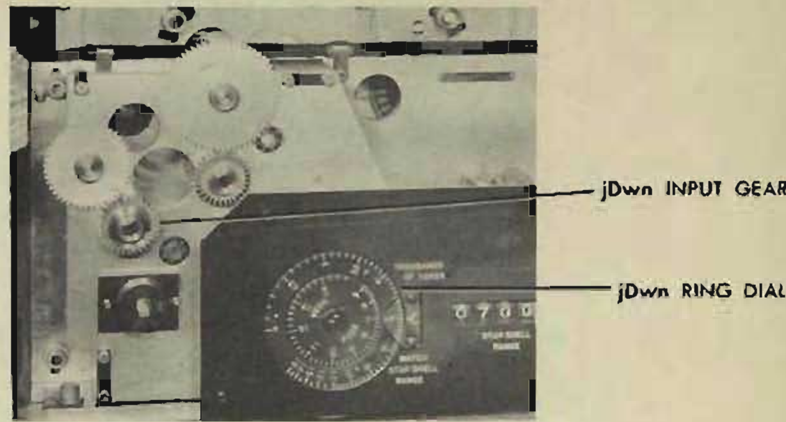
A-11 ALTERNATE METHOD of readjusting



Check

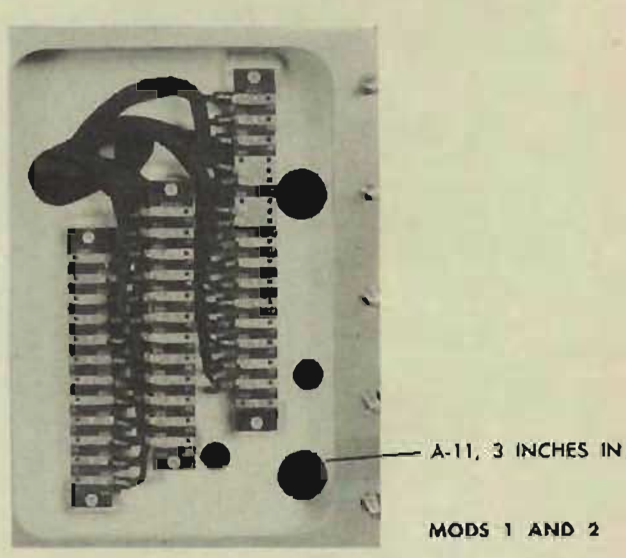
Wedge the *B'gr* input line from Computer Mark 1.
On Mods 1 and 2, wedge the *B'jn* line.
Set star shell deflection at 0 knots.
On Mods 0 and 1, set the *jDwn* ring dial at 5,000 yards; on Mod 2, at 8,000 yards. Read the *B'grn* dials (*B'grjn* dials on Mods 1 and 2).

Increase star shell deflection to 50.0 knots.
The reading on the *B'grn* (or *B'grjn*) dials should have increased 9°41' on Mods 0 and 1, or 6°03' on Mod 2.

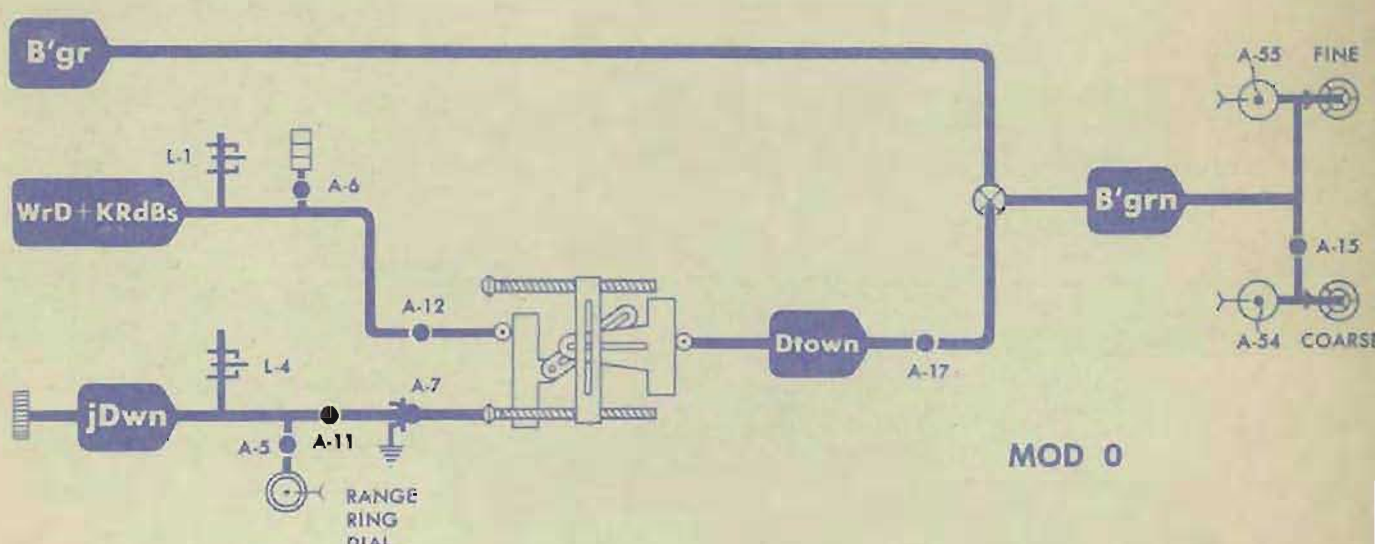


Adjustment

If the *B'grn* (or *B'grjn*) dials do not show the correct increase, slip-tighten A-11.
Turn the spur gear at the rear of A-11 until the change in *B'grn* (or *B'grjn*) is correct.
Tighten A-11, and recheck.
Remove the wedges.
Check A-17.

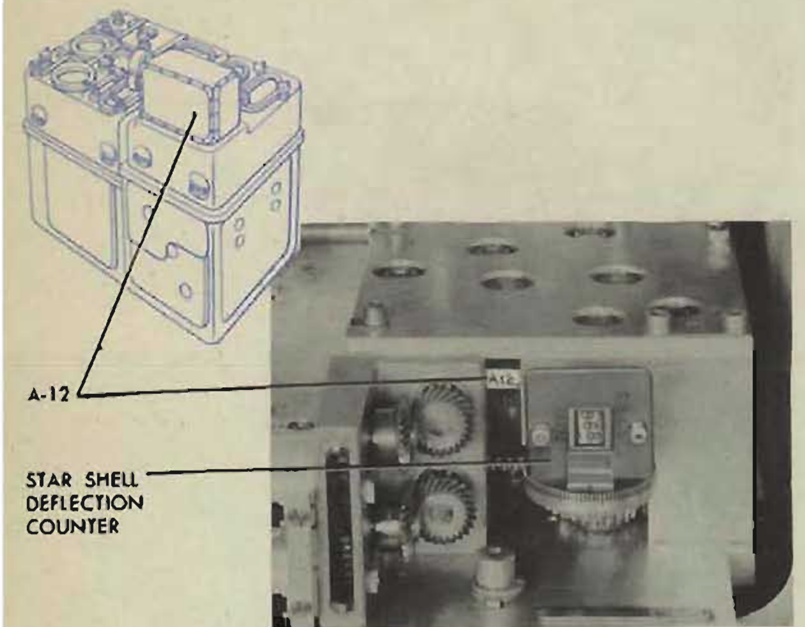


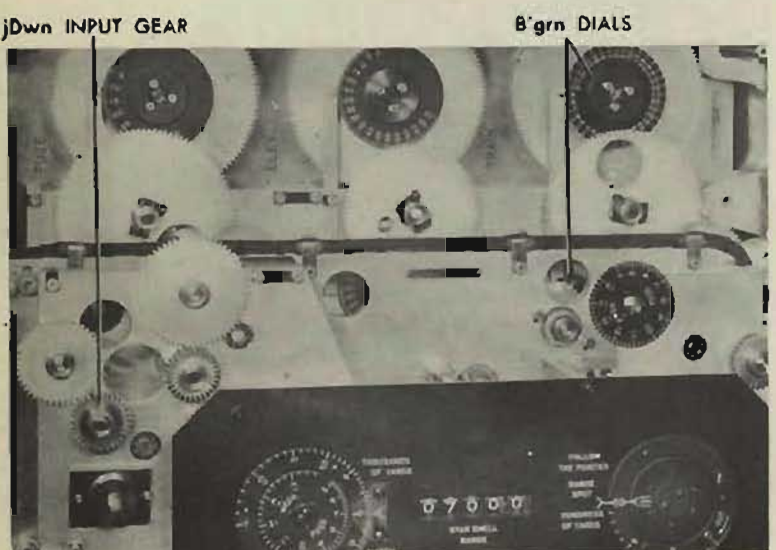
MODS 1 AND 2



MOD 0

A-12 DEFLECTION MULTIPLIER to STAR SHELL DEFLECTION COUNTER





Location

A-12 is under the rear cover.

Check

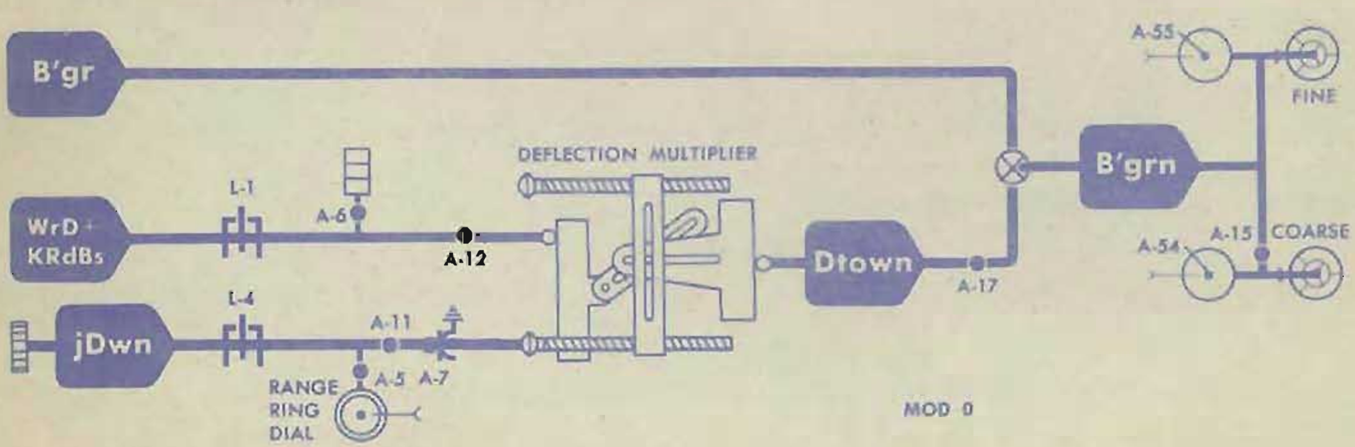
Turn the power OFF.

Set the star shell deflection counter at 0 by turning the gearing.
The *WrD + KRdBs* input slide to the deflection multiplier should be positioned so that turning the *jDwn* input gear produces no motion of the output slide.
Wedge the *B'gr* line from Computer Mark 1.
On Mods 1 and 2, wedge the *B'jn* line.
Turn the *jDwn* input gear.
The *B'grn* (*B'grjn* on Mods 1 and 2) dial reading should not change.

Adjustment

If the *B'grn* (or *B'grjn*) reading changes, slip-tighten A-12. Turn the spur gear at A-12 until there is no change in the *B'grn* (or *B'grjn*) dial reading when the *jDwn* input gear is turned through its full travel.

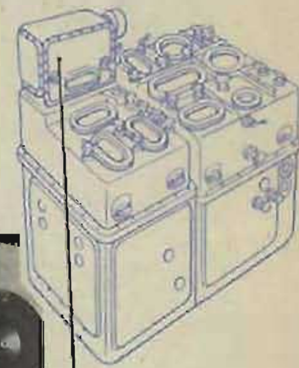
Tighten A-12, and recheck.
Remove the wedges.
Check A-17.



A-13 FINE to COARSE SYNCHRO— Fn TRANSMITTER

Location

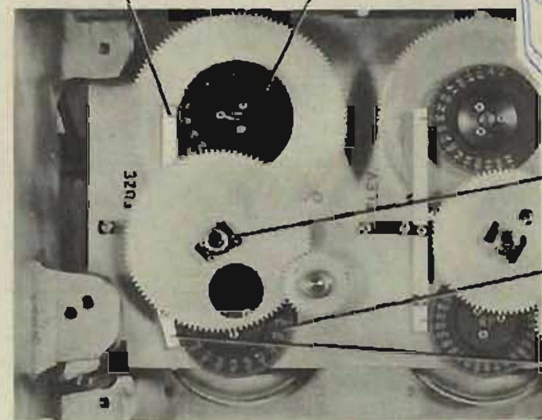
A-13 is under the front cover, in front of the star shell fuze order transmitters.



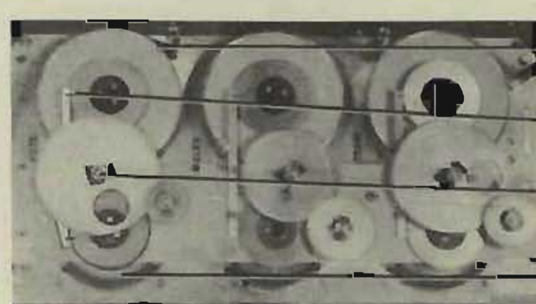
Check

Put the coarse fuze synchro on electrical zero. At that position, on Mod 0 the coarse dial reads 10; on Mods 1 and 2 the scribe mark is at the fixed index.

The fine synchro should also be on electrical zero.
On Mod 0 the fine dial should read 0.0; on Mods 1 and 2 the scribe mark should be at the fixed index.



MOD 0



MODS 1 AND 2

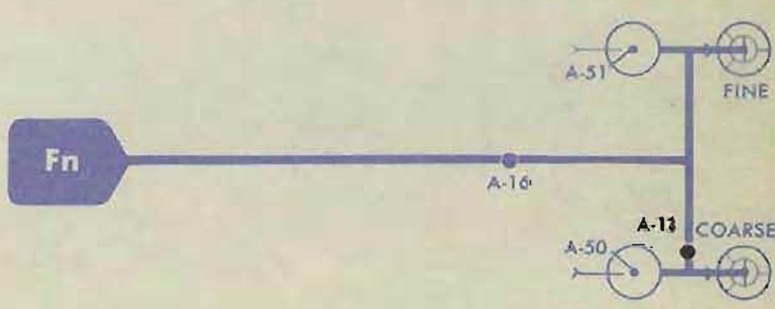
Adjustment

If the fine fuze synchro is not on electrical zero when the coarse synchro is on electrical zero, slip-tighten A-13. Hold the fine synchro on electrical zero, and turn the large spur gear on the coarse synchro until the coarse synchro is also on electrical zero.

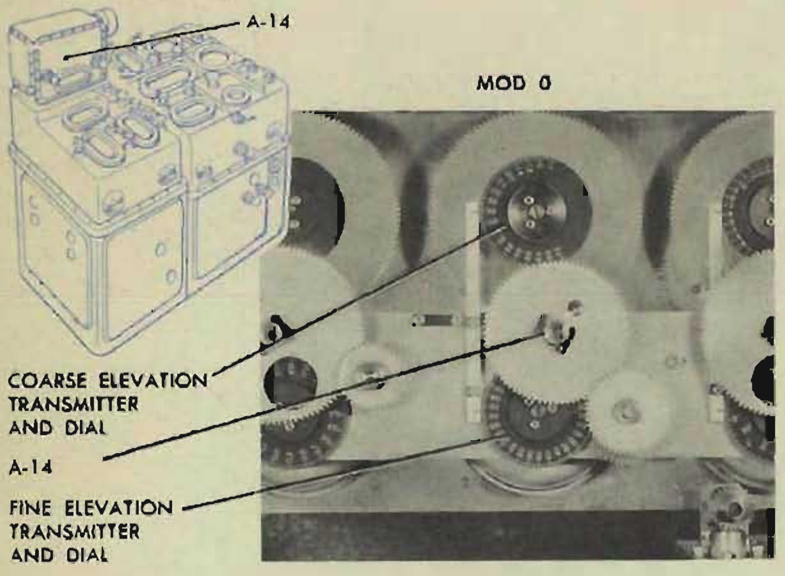
Tighten A-13, and recheck. Check A-16.

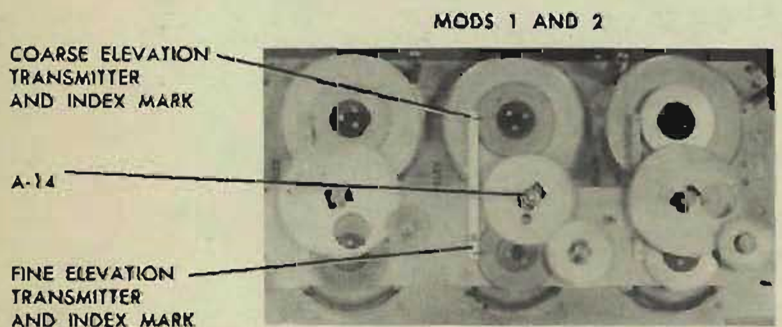
Note

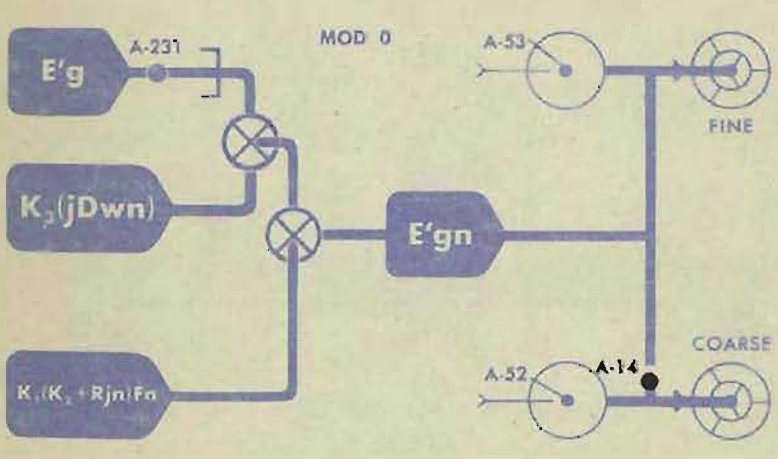
On Mod 0, the fine dial has two graduations marked 0.0 seconds. Use the same graduation in readjusting A-13 that was used for readjusting A-51.



A-14 FINE to COARSE SYNCHRO— E'gn TRANSMITTER







Location

A-14 is under the front cover, in front of the *E'gn* transmitters (*E'gjn* on Mods 1 and 2).

Check

Put the coarse *E'gn* (or *E'gjn*) synchro on electrical zero. At that position, on Mod 0 the coarse dial reads 20; on Mods 1 and 2 the scribe mark is at the fixed index.

The fine synchro should also be on electrical zero. On Mod 0, the fine dial should read 00; on Mods 1 and 2 the fine scribe mark should be at the fixed index.

Adjustment

If the fine synchro is not on electrical zero when the coarse synchro is on electrical zero, slip-tighten A-14. Hold the fine synchro on electrical zero. Turn the large spur gear on the coarse synchro until the coarse synchro is also on electrical zero.

Tighten A-14, and recheck.
Check A-231.

Note

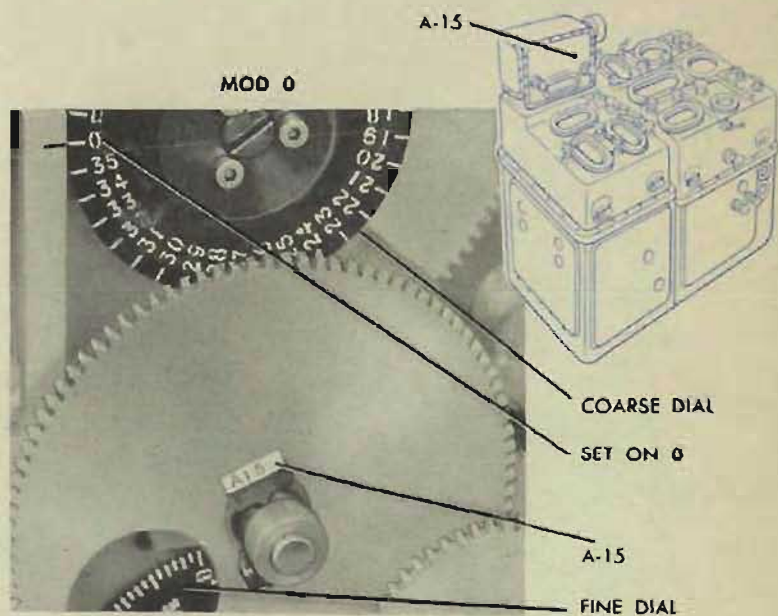
On Mod 0, there are six graduations marked 00 on the fine dial.
In readjusting A-14, use the same graduation that was used for readjusting A-53.

A-15 FINE to COARSE SYNCHRO— B'grn TRANSMITTER

Location

A-15 is under the front cover, in front of the *B'grn* transmitters (*B'grjn* on Mods 1 and 2).

MOD 0

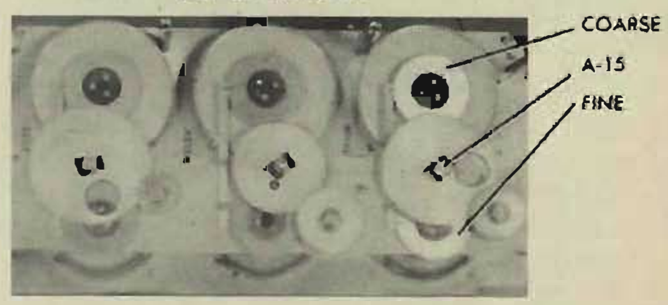


Check

Put the coarse *B'grn* (or *B'grjn*) synchro on electrical zero. At that position, on Mod 0 the coarse dial reads 0; on Mods 1 and 2 the scribe mark is at the fixed index.

The fine synchro also should be on electrical zero. On Mod 0 the fine dial should read 0; on Mods 1 and 2 the scribe mark should be at the fixed index.

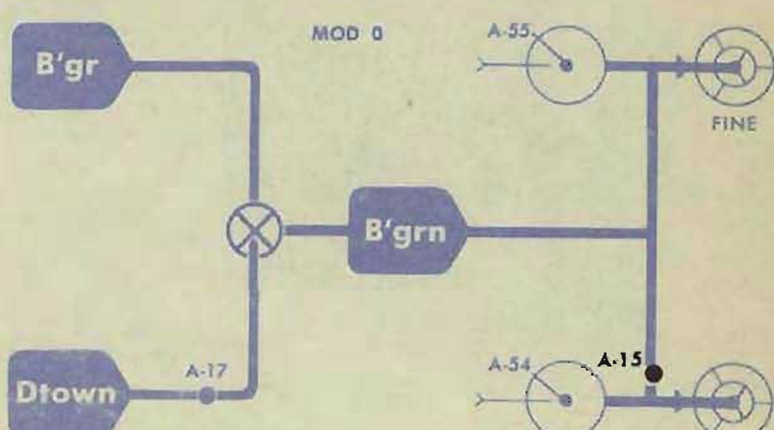
MODS 1 AND 2
SECTION REMOVED



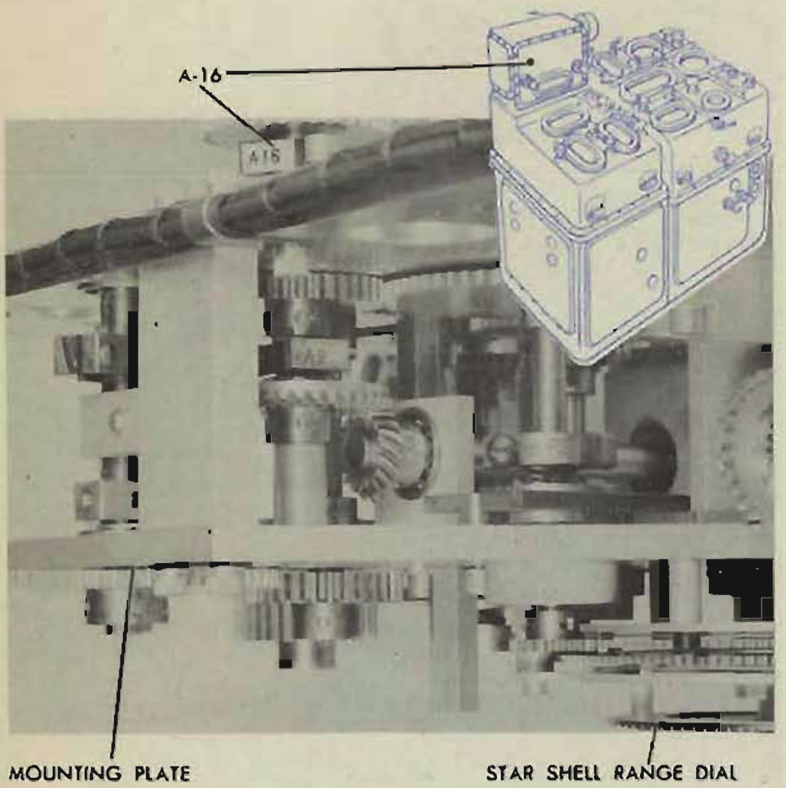
Adjustment

If the fine synchro is not on electrical zero when the coarse synchro is on electrical zero, slip-tighten A-15. Hold the fine synchro on electrical zero and turn the large spur gear on the coarse synchro until the coarse synchro is on electrical zero.

Tighten A-15, and recheck.
Check A-17.



A-16 MOD 0 Fn DIALS to L-3



Location

A-16 is under the front cover, in back of the mounting plate behind the dial mask.

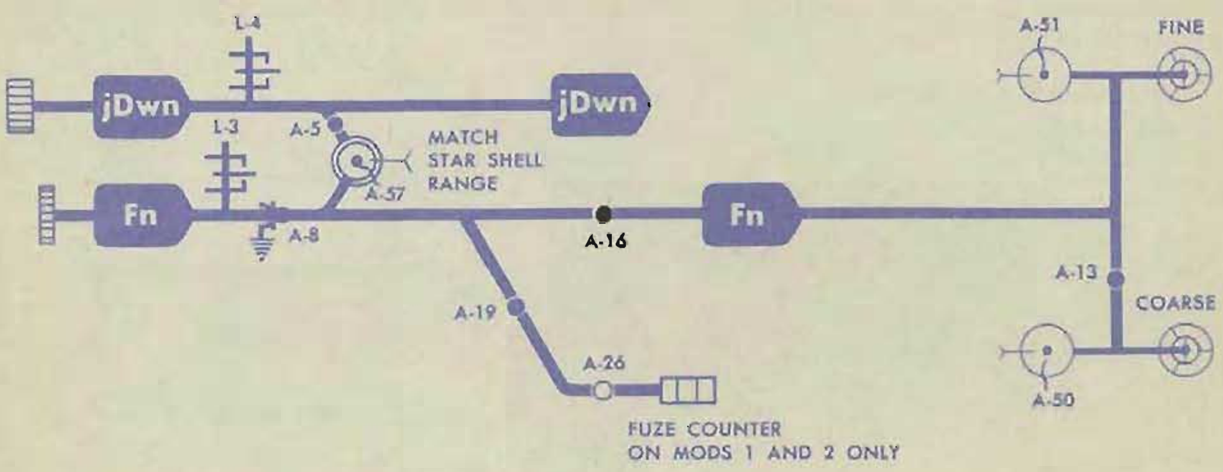
Check

L-3 should operate at 8.20 and 41.55 seconds.
Turn the *Fn* input gear to the lower limit of the stop.
The *Fn* dials should read 8.20 seconds.

Adjustment

If the *Fn* dials do not read 8.20 seconds, loosen A-16.
Hold the *Fn* line against the stop, and turn the large spur gear above A-16 until the dial reading is correct.

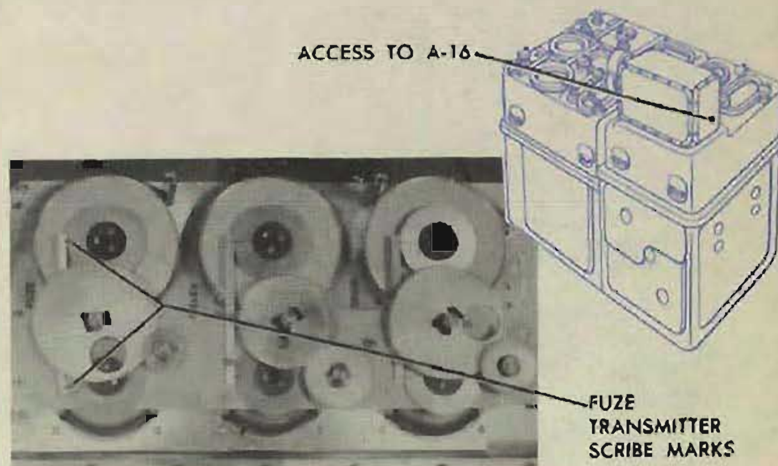
Tighten A-16, and check at the upper limit.



A-16 MODS 1 and 2 Fn TRANSMITTER to Fn COUNTER

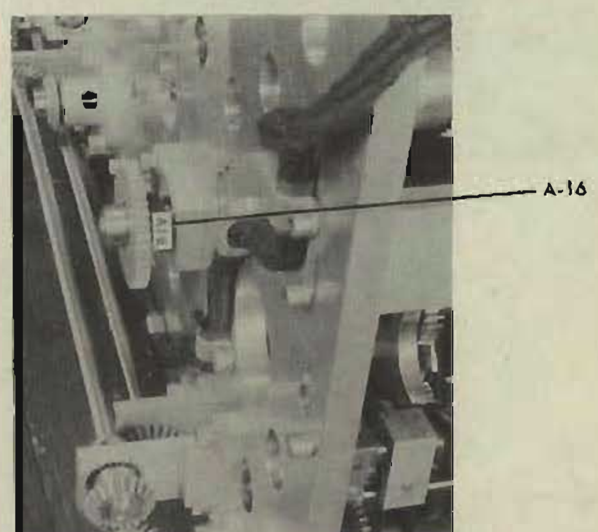
Location

A-16 is under the front cover and is accessible through a hole under the junction box cover.



Check

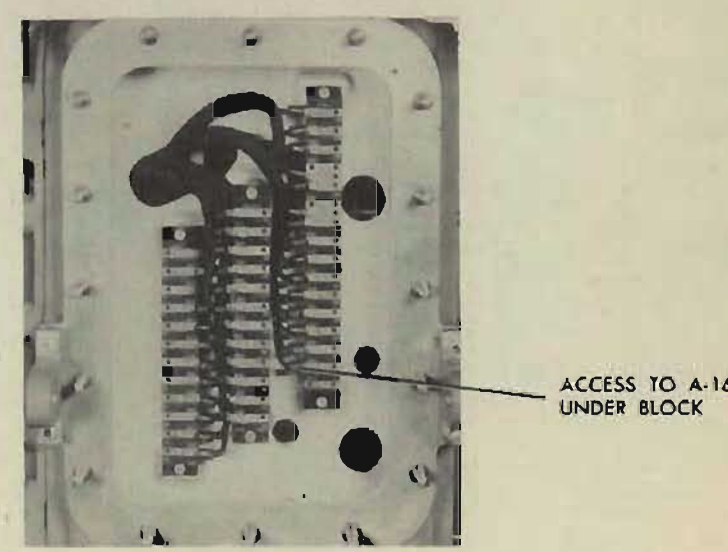
Set the *Fn* counter at 10.00 seconds. The *Fn* transmitter scribe marks should be at the fixed indexes.



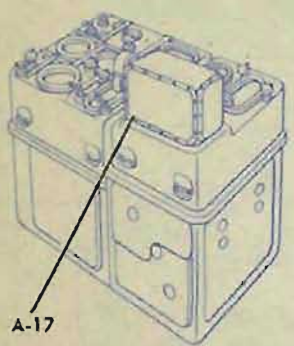
Adjustment

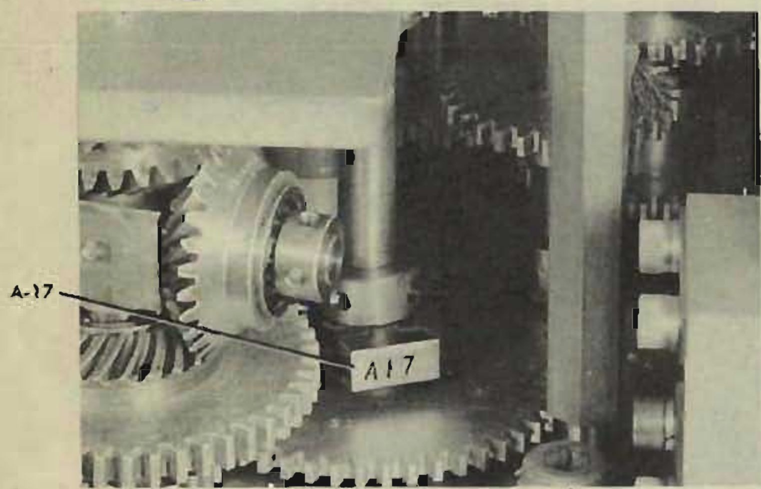
If the *Fn* transmitter scribe marks are not at the fixed indexes, loosen A-16. Hold the counter at 10.00 seconds. Turn the gear on which A-16 is mounted until the transmitter scribe marks are at the index marks.

Tighten A-16, and recheck.
Check A-19.



A-17 B′grn DIALS to B′gr DIALS





Location

A-17 is under the rear cover, just above the base plate.

Note

On Mods 1 and 2, check A-23 before readjusting A-17.

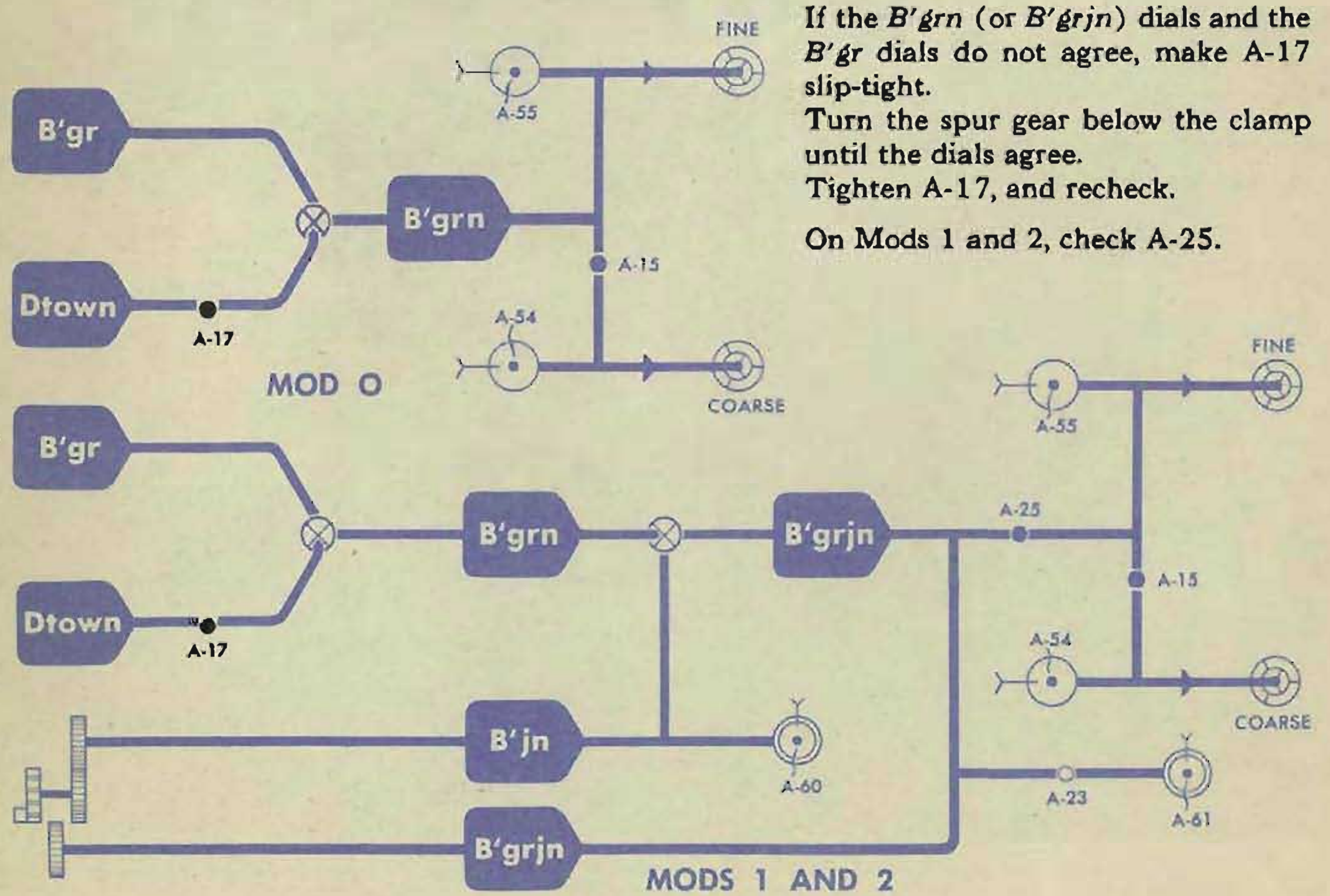
Check

Turn the power OFF.
Set the star shell deflection counter at 0 knots by turning the gearing. On Mods 1 and 2 also set the *B′jn* dials at 0.
The *B′grn* dials (or *B′grjn* dials on Mods 1 and 2) should match the *B′gr* dials.

Adjustment

If the *B′grn* (or *B′grjn*) dials and the *B′gr* dials do not agree, make A-17 slip-tight.
Turn the spur gear below the clamp until the dials agree.
Tighten A-17, and recheck.

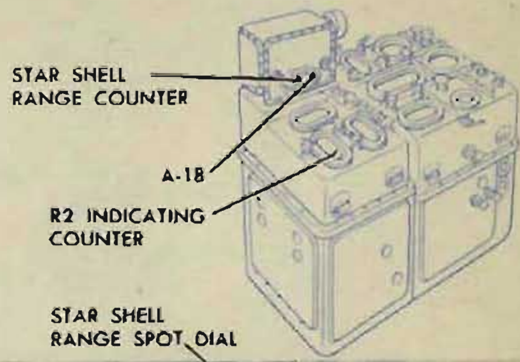
On Mods 1 and 2, check A-25.



A-18 R2n COUNTER to R2 COUNTER

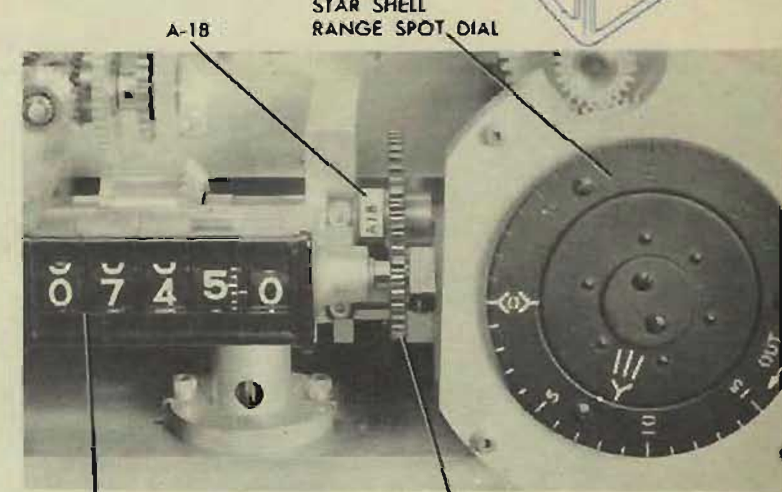
Location

A-18 is under the front cover, on a spur gear next to the star shell range counter.



Check

Set *Rjn* at 0.
The *R2n* counter should read 1,000 yards more than the *R2* counter in the Computer Mark 1.

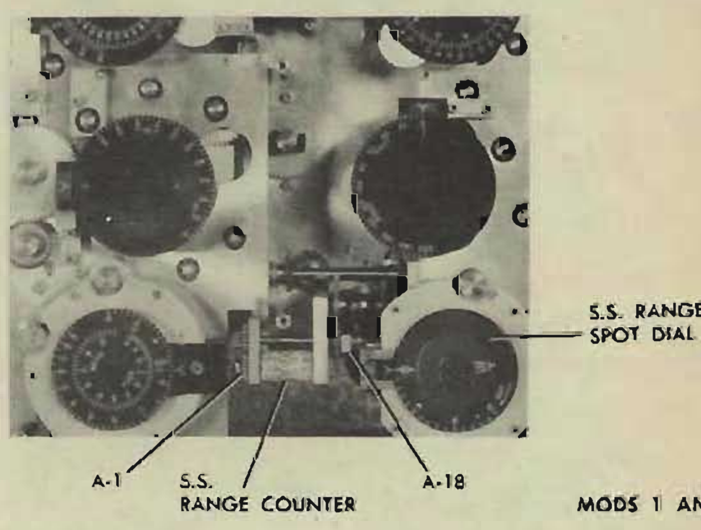


MOD 0

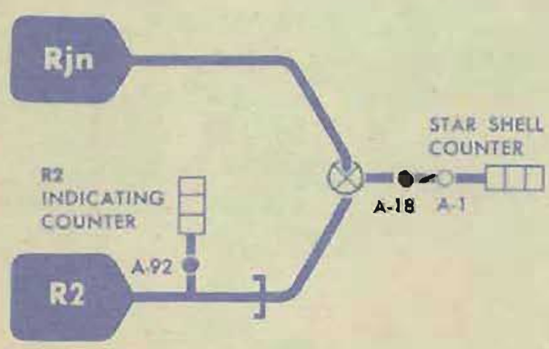
Adjustment

If the *R2n* counter does not read 1,000 yards more than the *R2* counter, loosen A-18. Turn the gear on the counter shaft until the reading is correct.

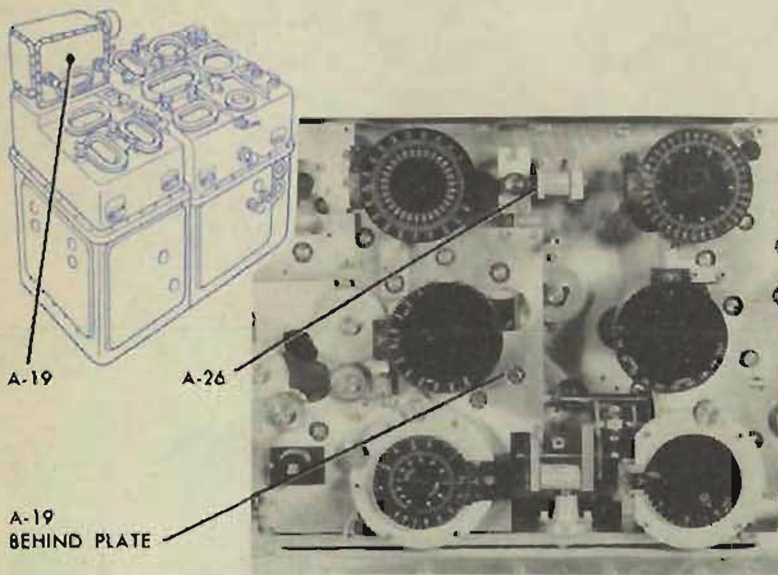
Tighten A-18, and recheck.
Check that assembly clamp A-1 is tight.

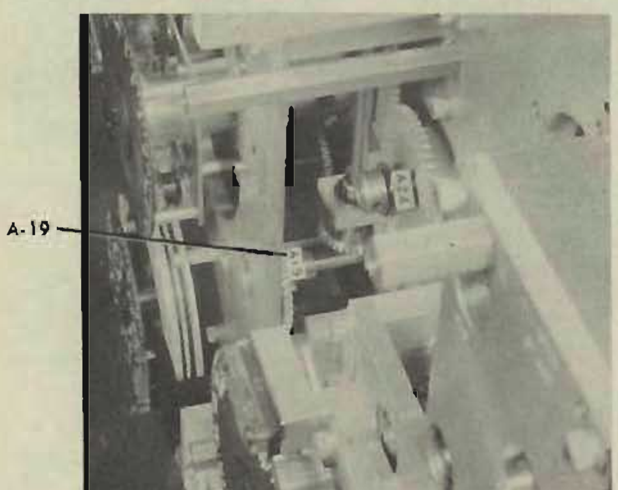


MODS 1 AND 2



A-19 Fn COUNTER to L-3





Location

A-19 is under the front cover, behind the plate to the right of the elevation spot dial.

Check

Decrease *Fn* to the lower limit.
On Mod 1 the *Fn* counter should read 8.20 seconds; on Mod 2, 9.70 seconds.

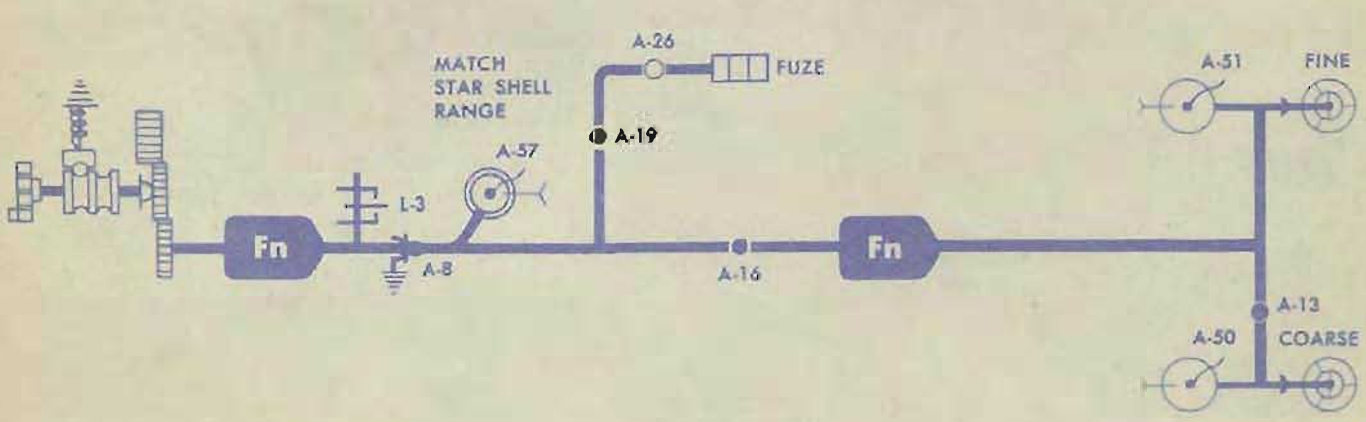
Increase *Fn* to the upper limit.
On Mod 1, the *Fn* counter should read 41.55 seconds; on Mod 2, 46.70 seconds.

Check that A-26 is tight, before re-adjusting A-19.

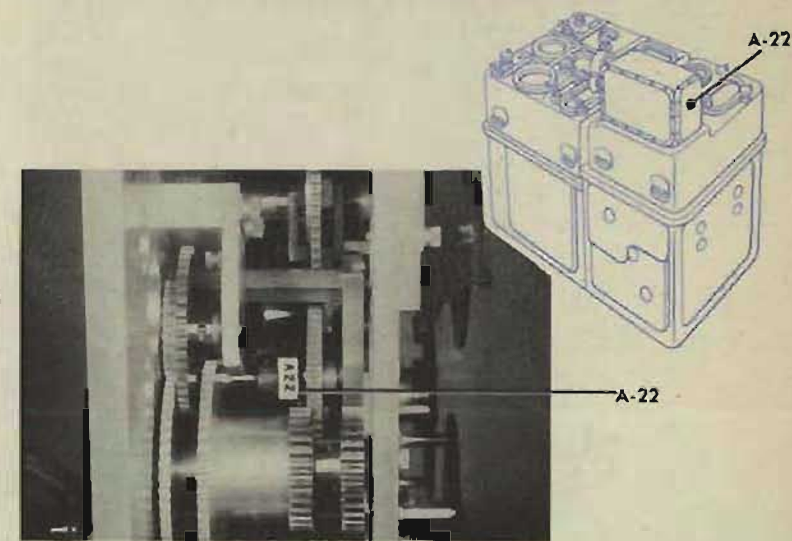
Adjustment

If the *Fn* counter reading is incorrect at either limit, loosen A-19.
Hold the line against the stop and set the counter at the proper reading.

Tighten A-19, and recheck.
Split any overtravel.
Check A-16 and A-57.



A-22 ASSEMBLY CLAMP



Location

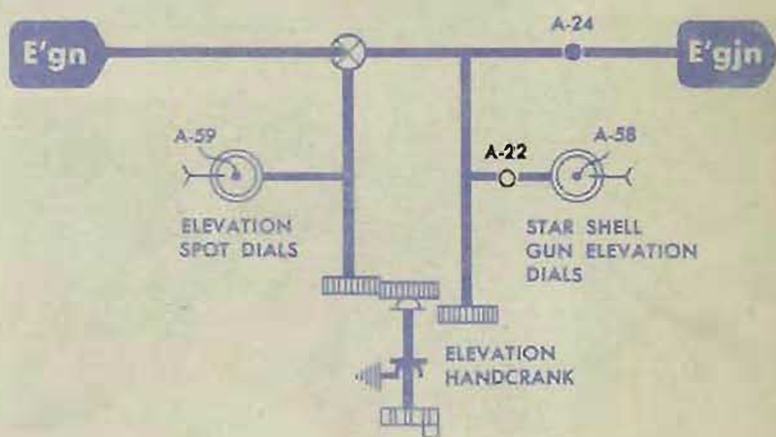
A-22 is under the front cover, behind the plate supporting the *E'gjn* dials. It is accessible through a hole under the junction box cover.

Check

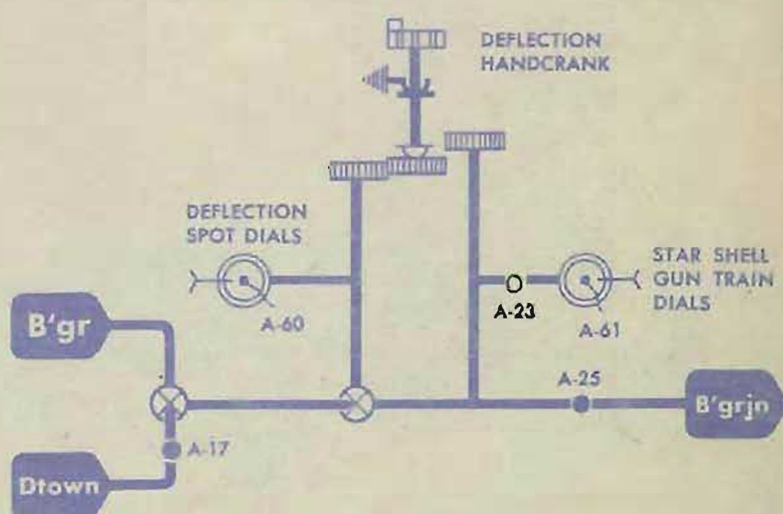
A-22 should be tight.

Adjustment

Tighten A-22.
Check A-24 and A-231.



A-23 ASSEMBLY CLAMP

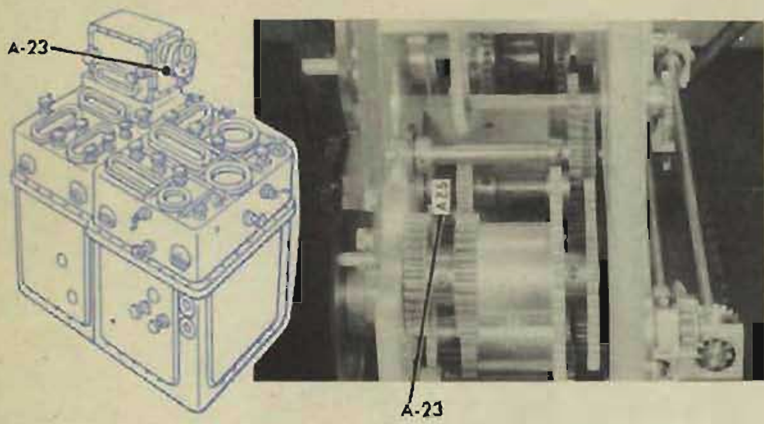


Location

A-23 is under the front cover, behind the plate supporting the *B'grjn* dials. It is accessible through a hole on the right side.

Check

A-23 should be tight.

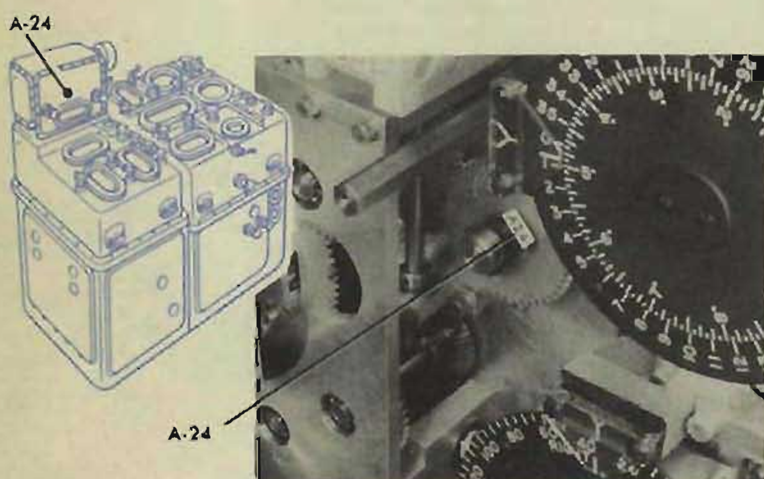


Adjustment

Tighten A-23.

Check A-25 and A-17.

A-24 E′gjn TRANSMITTER to E′gjn DIALS



Location

A-24 is under the front cover, below the *Fn* counter.

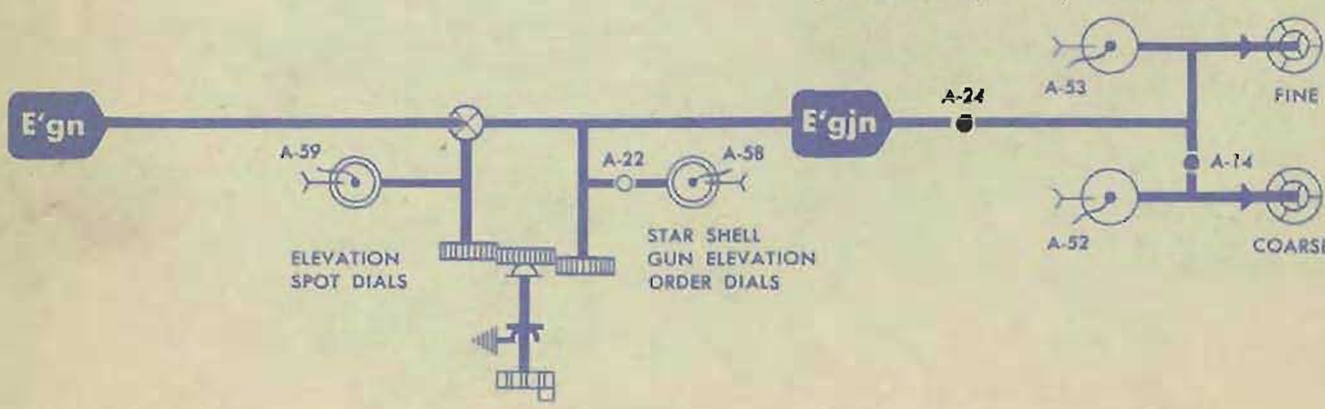
Check

Set the *E′gjn* dials at 2000′.
The scribe marks on the fine and coarse transmitter dials should match the fixed indexes.
Check that A-22 is tight, before re-adjusting A-24.

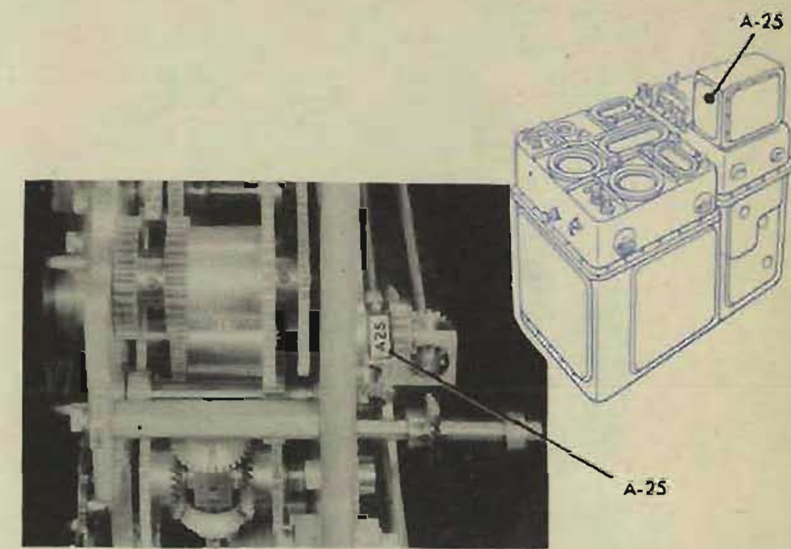
Adjustment

If the scribe marks do not match the fixed indexes, loosen A-24.
Turn the transmitter gearing to align the scribe marks at the fixed indexes.

Tighten A-24, and recheck.
Check A-52, A-53, and A-14.



A-25 B'grjn TRANSMITTER to B'grjn DIALS

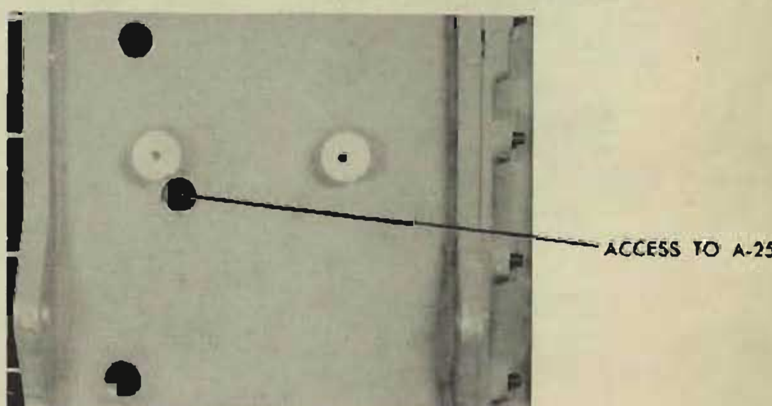


Location

A-25 is accessible through a hole at the right side.

Check

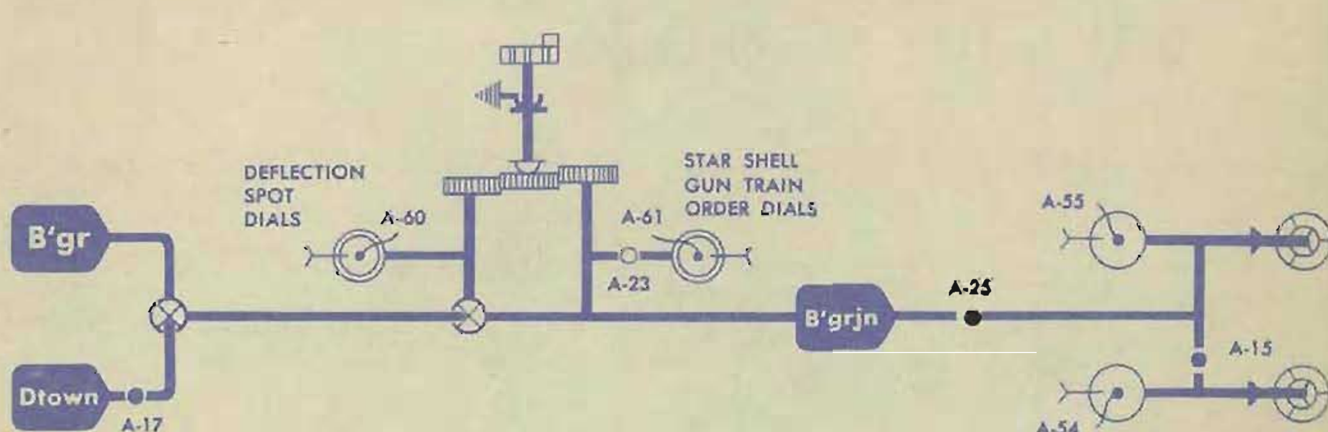
Set the *B'grjn* dials at 0°.
The scribe marks on the fine and coarse transmitter dials should match the fixed indexes.
Check that A-23 is tight before re-adjusting A-25.



Adjustment

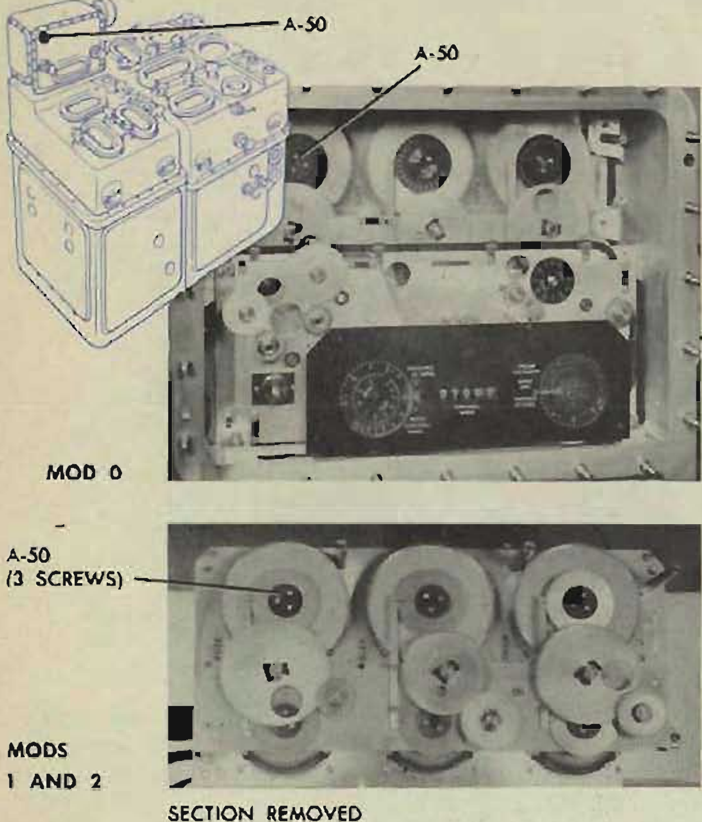
If the scribe marks do not match the fixed indexes, loosen A-25. Turn the transmitter gearing to align the scribe marks at the fixed indexes.

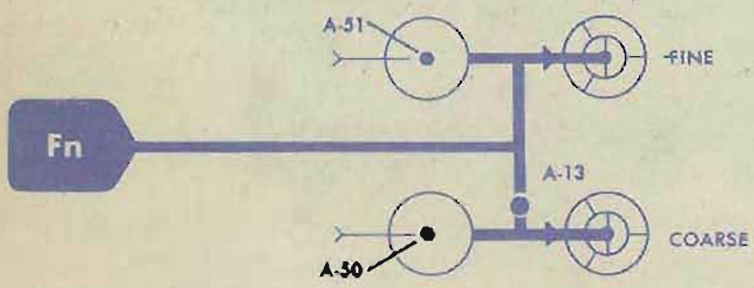
Tighten A-25, and recheck.
Check A-54, A-55, and A-15.



A-26 ASSEMBLY CLAMP (see A-19)

A-50 DIAL to COARSE Fn SYNCHRO





Location

A-50 is under the front cover, on the coarse *Fn* transmitter dial.

On Mods 1 and 2, A-50 is accessible only after the transmitter section is removed from the star shell computer.

Check

Set the coarse *Fn* synchro at electrical zero.

On Mod 0, the coarse *Fn* dial should read 10 seconds. On Mods 1 and 2, the scribe mark should be at the fixed index.

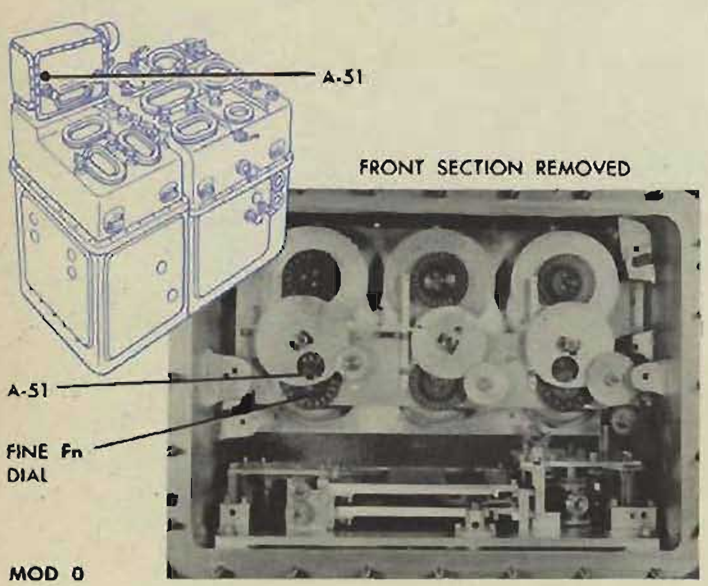
Adjustment

If the coarse *Fn* dial does not read 10 seconds, or the scribe mark is not at the fixed index, loosen A-50. Slip the dial to the correct position.

Tighten A-50 and recheck.

Check A-13 and A-16.

A-51 DIAL to FINE Fn SYNCHRO



Location

A-51 is under the front cover, on the fine *Fn* transmitter dial.

Check

Set the fine *Fn* synchro at electrical zero.

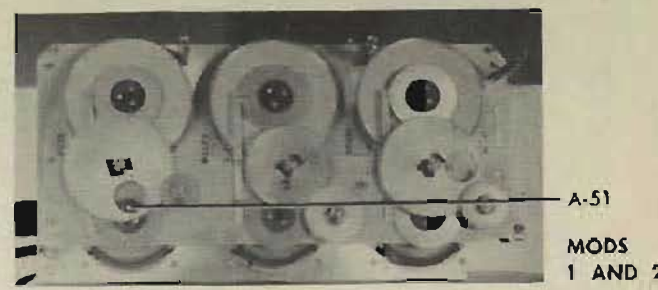
On Mod 0, the fine *Fn* dial should read 0.00 seconds. On Mods 1 and 2, the scribe mark should be at the fixed index.

Adjustment

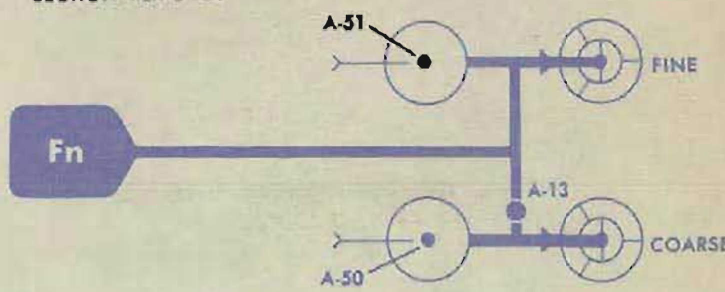
If the fine *Fn* dial does not read 0.00, or the scribe mark is not at the fixed index, loosen A-51. Slip the dial to the correct position.

Tighten A-51 and recheck.

Check A-13 and A-16.



SECTION REMOVED



A-52 DIAL to COARSE E'gjn SYNCHRO

Location

A-52 is under the front cover, on the coarse *E'gjn* transmitter.

Check

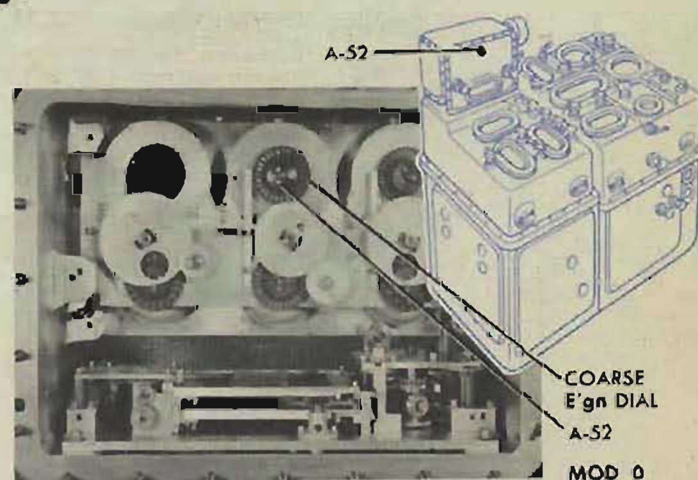
Set the coarse *E'gjn* synchro at electrical zero.
On Mod 0, the coarse *E'gn* dial should read 20. On Mods 1 and 2, the scribe mark should be at the fixed index.

Adjustment

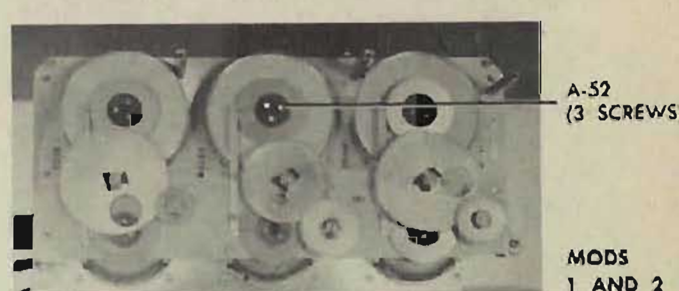
If the coarse *E'gn* dial does not read 20, or the scribe mark is not at the fixed index, loosen A-52. Slip the dial to the correct position.

Tighten A-52 and recheck.

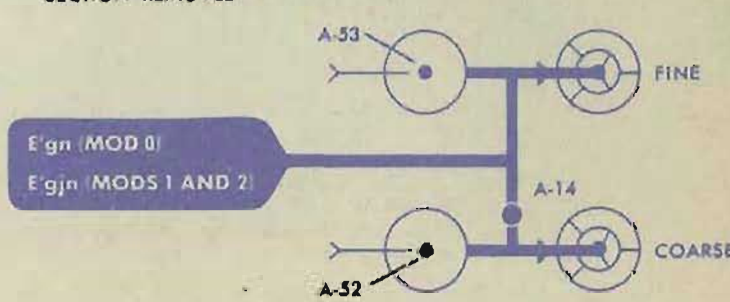
Check A-14.



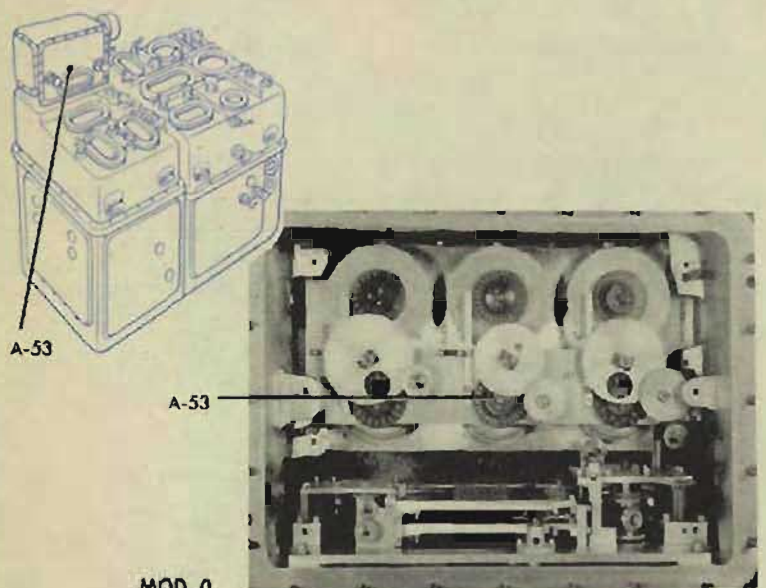
FRONT SECTION REMOVED



SECTION REMOVED

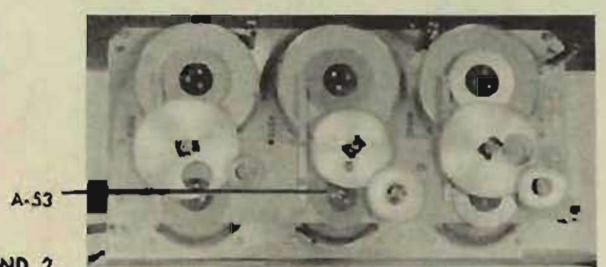


A-53 DIAL to FINE E'gjn SYNCHRO



MOD 0

FRONT SECTION REMOVED



MODS 1 AND 2

SECTION REMOVED

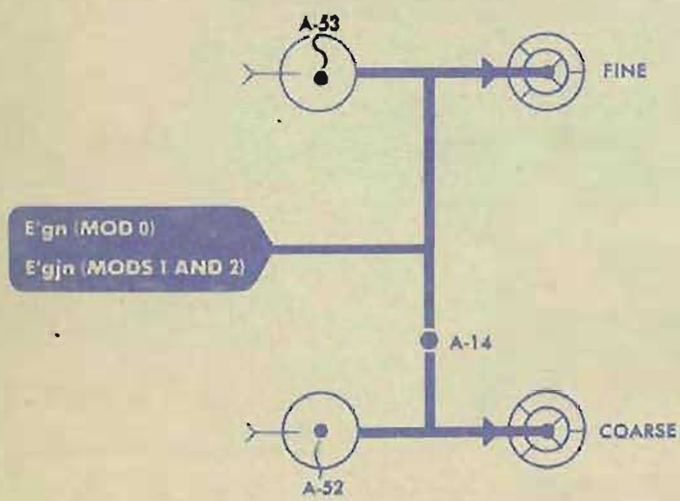
Location

A-53 is under the front cover, on the fine *E'gjn* transmitter dial.

Check

Set the fine *E'gjn* synchro at electrical zero.
On Mod 0, the fine *E'gn* dial should read 00. On Mods 1 and 2, the scribe mark should be at the fixed index.

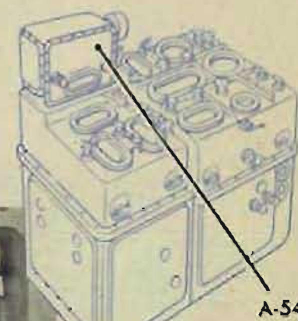
Adjustment

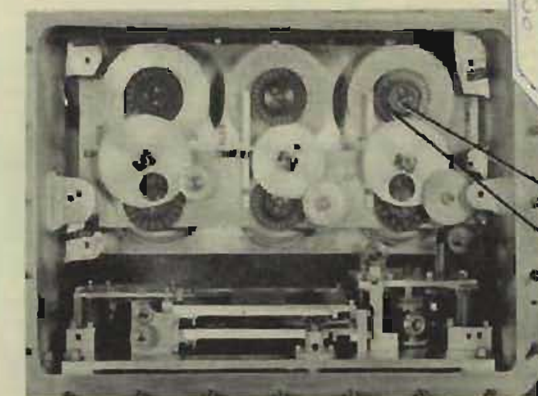


If the fine *E'gn* dial does not read 00 or the scribe mark is not at the fixed index, loosen A-53. Slip the dial to the correct position.

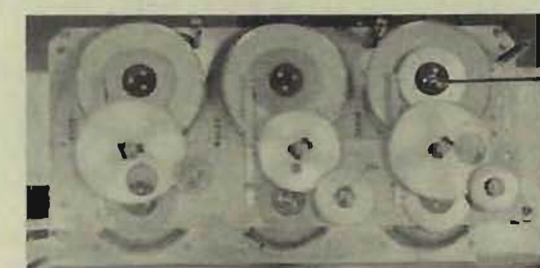
Tighten A-53 and recheck.
Check A-14.

A-54 DIAL to COARSE B'grjn SYNCHRO





FRONT SECTION REMOVED



SECTION REMOVED

Location

A-54 is under the front cover, on the coarse *B'grjn* transmitter dial.

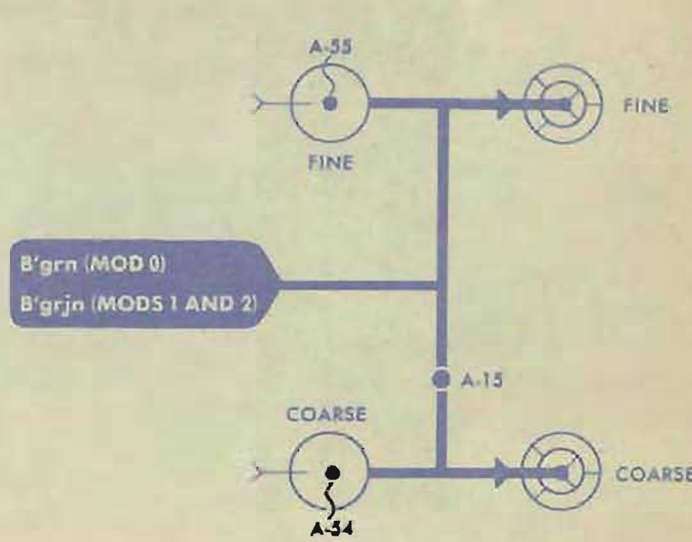
Check

Set the coarse *B'grjn* synchro at electrical zero.
On Mod 0, the coarse *B'grn* dial should read 0. On Mods 1 and 2, the scribe mark should be at the fixed index.

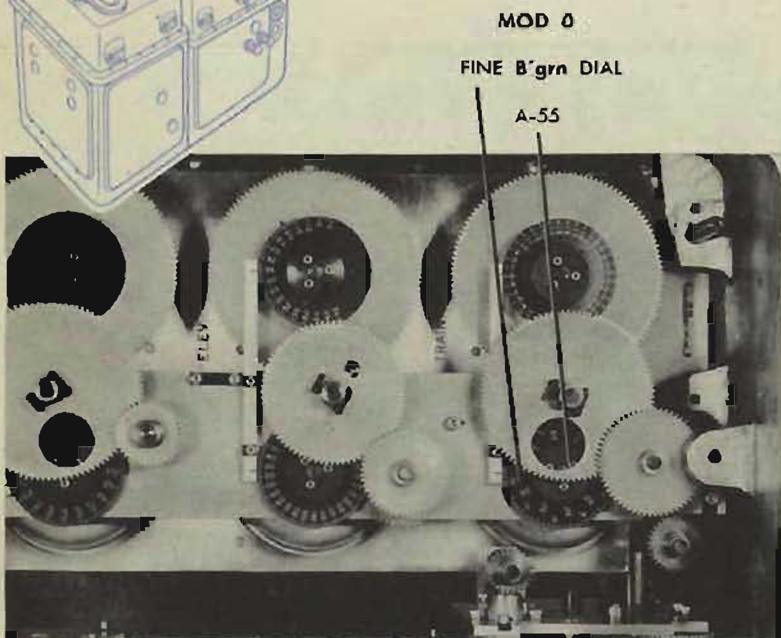
Adjustment

If the coarse *B'grn* dial does not read 0, or the scribe mark is not at the fixed index, loosen A-54. Slip the dial to the correct position.

Tighten A-54, and recheck.
Check A-15.



A-55 DIAL to FINE B'grjn SYNCHRO

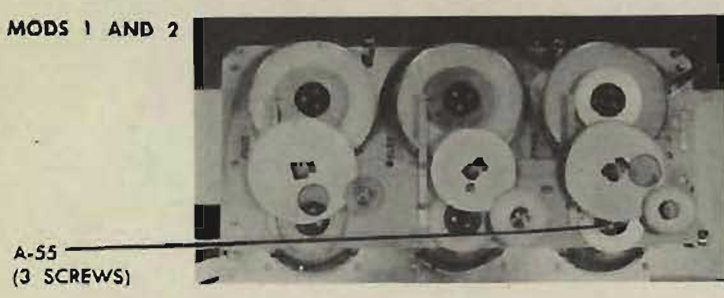


Location

A-55 is under the front cover, on the fine *B'grjn* transmitter dial.

Check

Set the fine *B'grjn* synchro at electrical zero.
On Mod 0 the fine *B'grn* dial should read 0°. On Mods 1 and 2, the scribe mark should be at the fixed index.

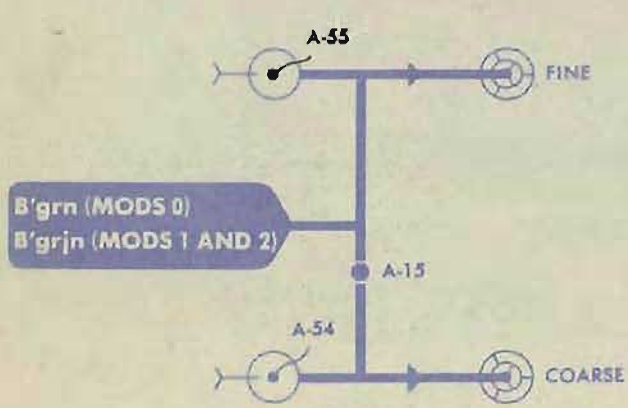


Adjustment

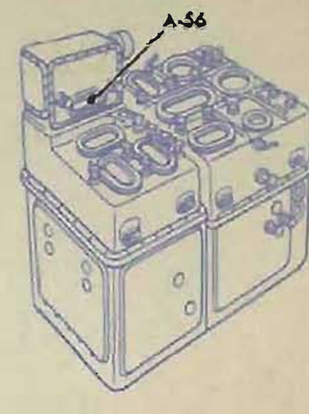
If the fine *B'grn* dial does not read 0°, or the scribe mark is not at the fixed index, loosen A-55. Slip the dial to the correct position.

Tighten A-55, and recheck.

Check A-15.

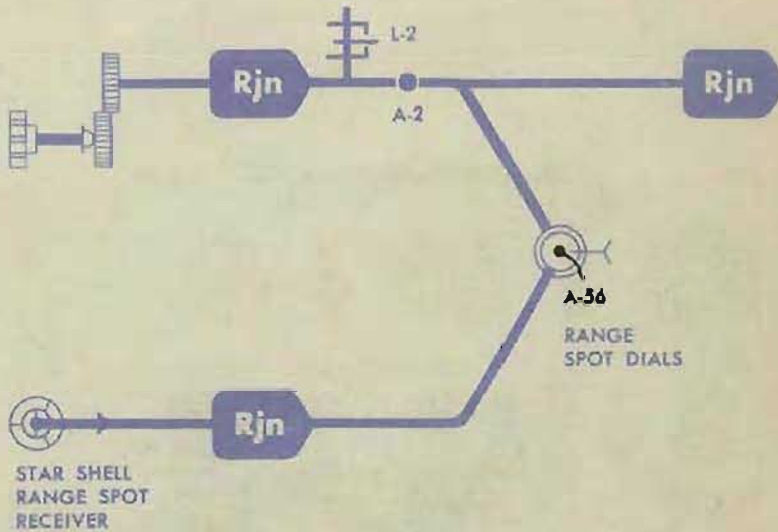


A-56 DIAL to Rjn SYNCHRO



Location

A-56 is under the front cover, on the inner *Rjn* dial.



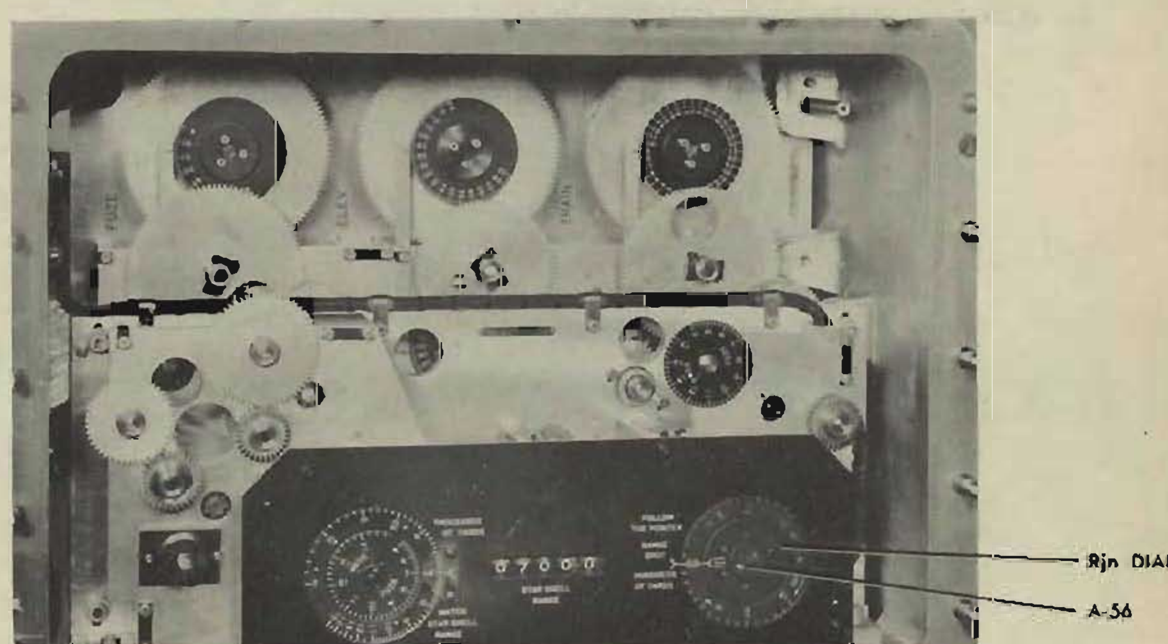
Check

Set the *Rjn* synchro at electrical zero. The pointer on the inner *Rjn* dial should match the fixed index.

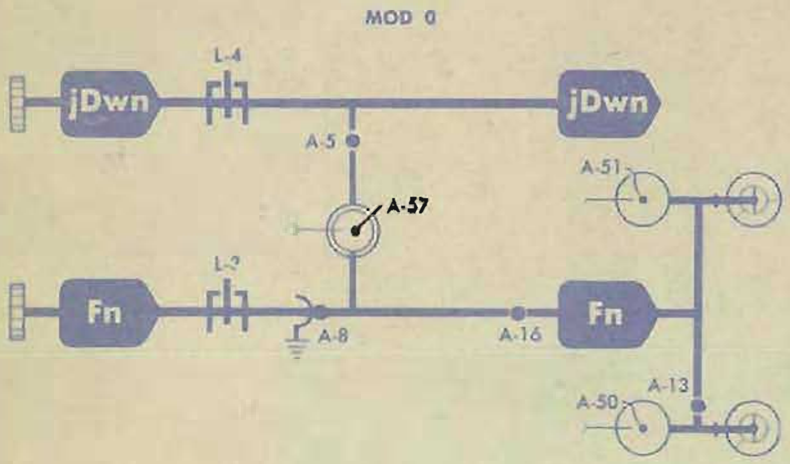
Adjustment

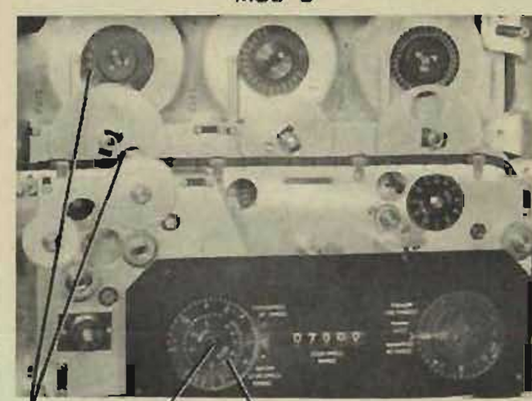
If the pointer on the *Rjn* dial does not match the fixed index, loosen A-56. Slip the dial to the correct position.

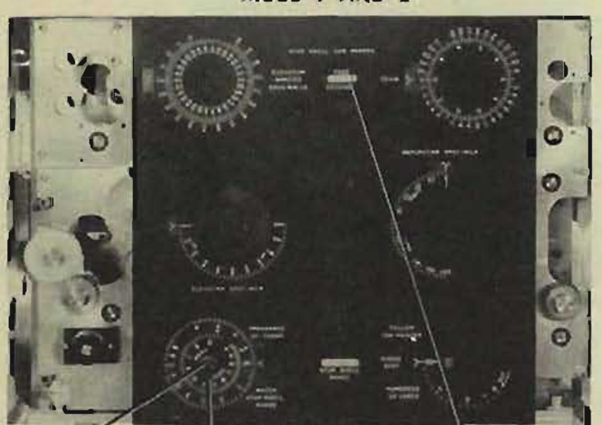
Tighten A-56, and recheck.

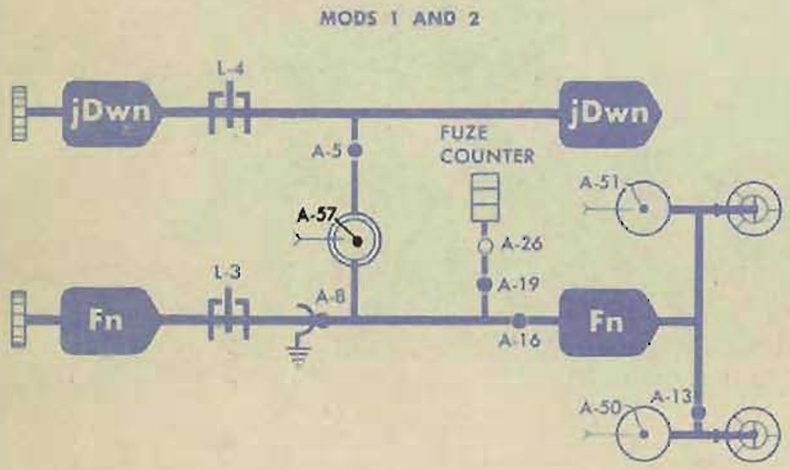


A-57 FUZE RANGE DIAL to Fn DIALS









Location

A-57 is under the front cover, on the fuze range dial.

Check

For powder fuze, Mod 0:
Set the *Fn* dials at 10.60 seconds.
The fuze range dial should read 5,000 yards.

For mechanical fuze, Mod 0:
Set the *Fn* dials at 14.50 seconds.
The fuze range dial should read 7,600 yards.

For mechanical fuze, Mod 1:
Set the *Fn* counter at 14.50 seconds.
The fuze range dial should read 7,600 yards.

For mechanical fuze, Mod 2:
Set the *Fn* counter at 20.02 seconds.
The fuze range dial should read 12,000 yards.

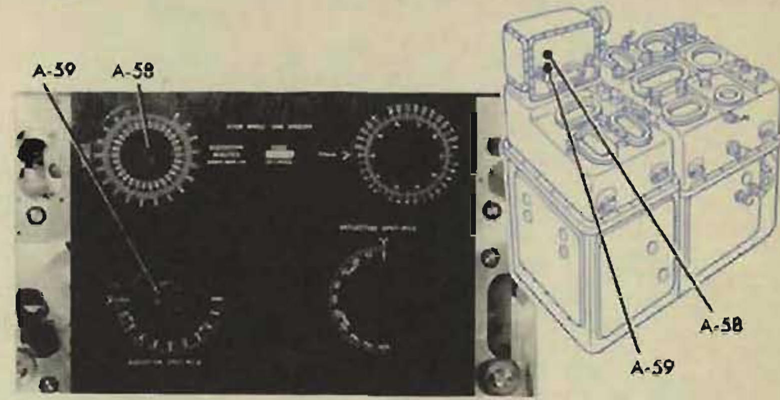
Adjustment

If the fuze range dial does not read the correct value, loosen A-57. Slip the dial to the correct reading.

Tighten A-57, and recheck.

Readjust A-231.

A-58 FINE to COARSE E'gjn DIAL



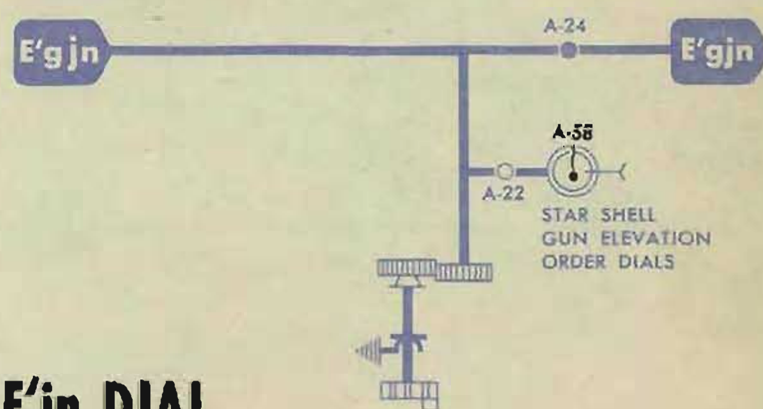
Location

A-58 is under the front cover, on the fine *E'gjn* dial.

Check

When the ring dial is at 20, the fine inner dial should be at 00. (Any one of the six 00 graduations may be used.)

Adjustment



If the inner dial is not at 00, loosen A-58. Slip the inner dial to read 00.

Tighten A-58, and recheck.
Check A-24 in the star shell computer, and A-231 in Computer Mark 1.

A-59 COARSE to FINE E'jn DIAL

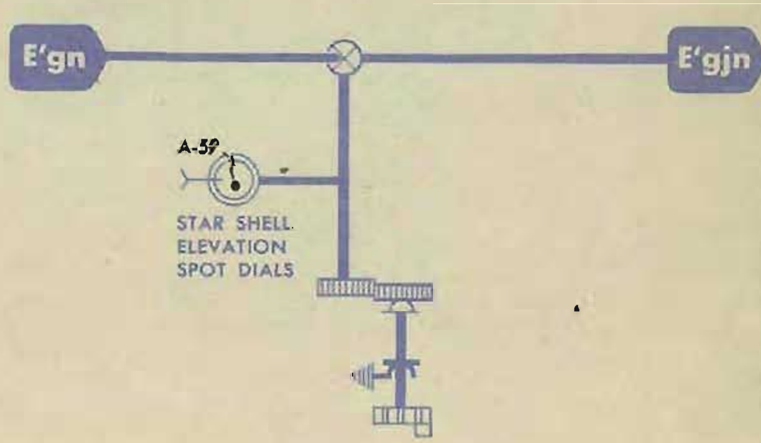
Location

A-59 is under the front cover, on the coarse *E'jn* dial.

Check

Set the 0 of the ring dial at the fixed index.
The center graduation on the inner dial should match the fixed index.

Adjustment

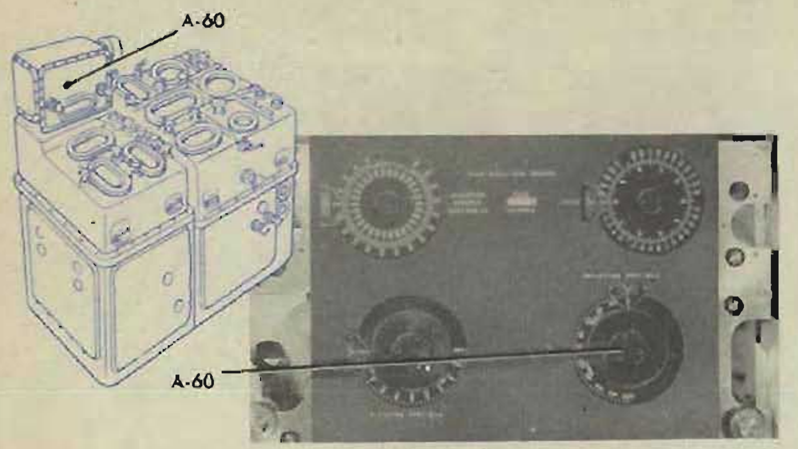


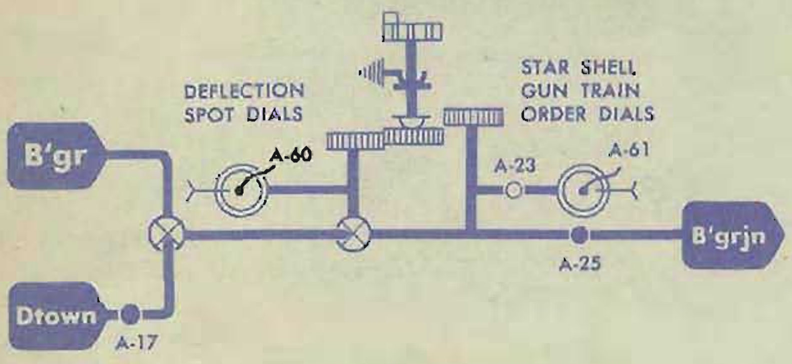
If the center graduation on the inner dial does not match the fixed index, loosen A-59. Slip the dial to the correct position.

Tighten A-59, and recheck.

Check A-231 in Computer Mark 1.

A-60 COARSE to FINE B'jn DIAL





Location

A-60 is under the front cover, on the coarse *B'jn* dial.

Check

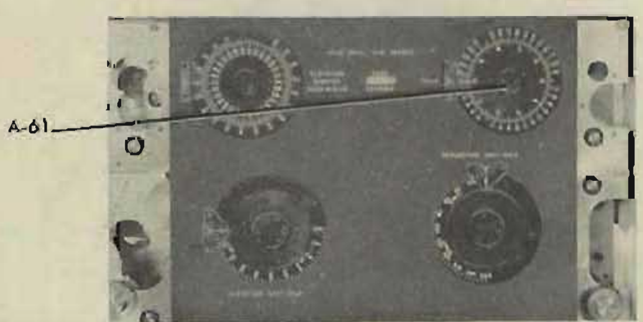
Set the 0 of the *B'jn* ring dial at the fixed index.
The center graduation of the inner dial should match the fixed index.

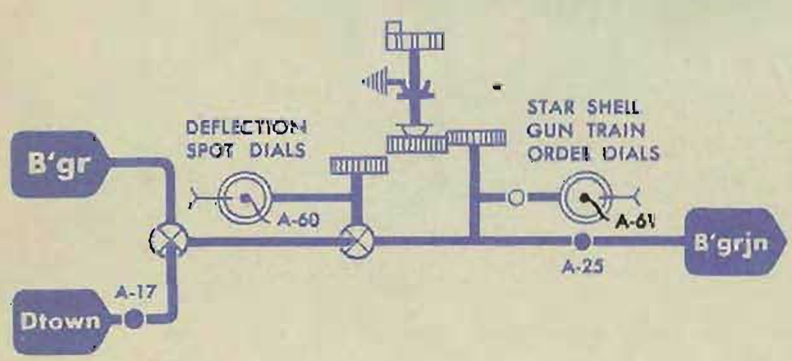
Adjustment

If the center graduation does not match the fixed index, loosen A-60. Slip the dial to the correct position.

Tighten A-60, and recheck.
Check A-17.

A-61 FINE to COARSE B'grjn DIAL





Location

A-61 is under the front cover, on the fine *B'grjn* dial.

Check

When the coarse dial is at 0, the fine dial should also be at 0.

Adjustment

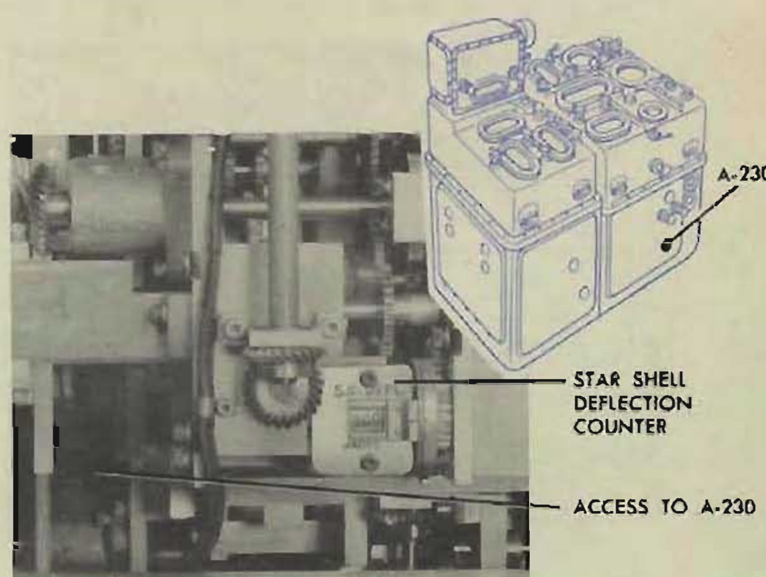
If the fine dial is not at 0, loosen A-61. Slip the fine dial to the correct position.

Tighten A-61, and recheck.
Check A-25 and A-17.

A-230 SYNCHRONIZING THE STAR SHELL DEFLECTION FOLLOW-UP

Location

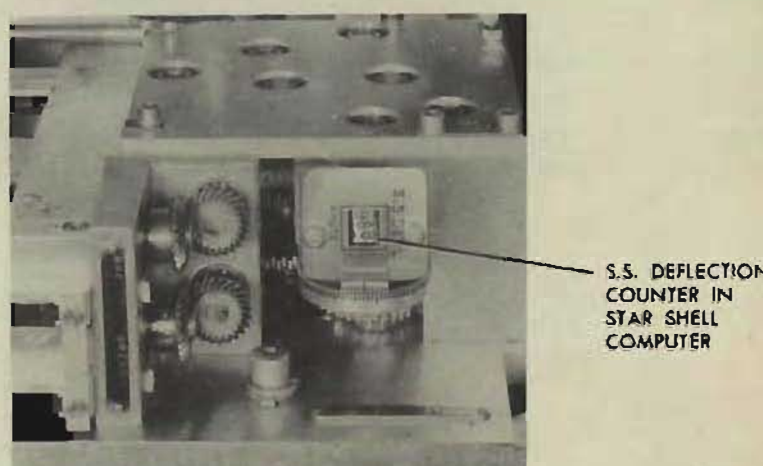
A-230 is under cover 3 of Computer Mark 1.



Check

Turn the power ON.

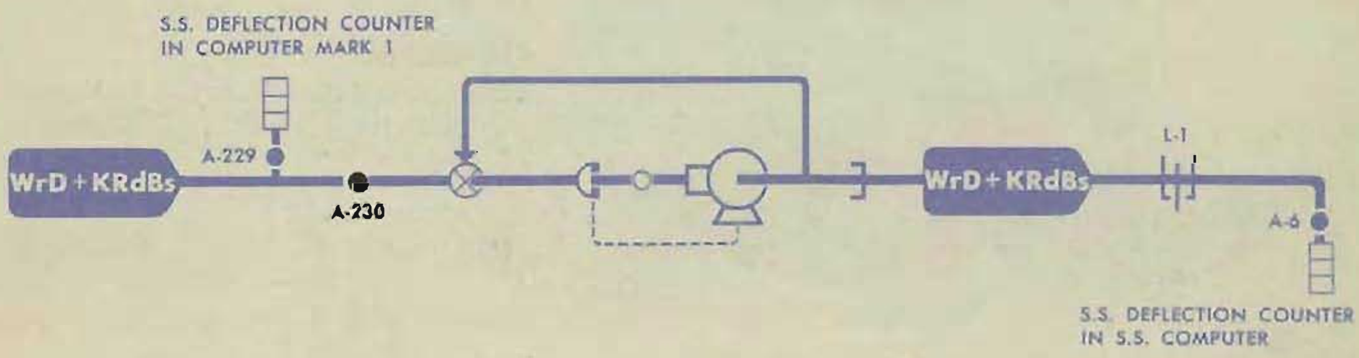
Set *Sw*, *So*, and *Sh* at 0 knots.
The star shell deflection counter in the star shell computer and the star shell deflection counter in Computer Mark 1 should both read 0 knots.



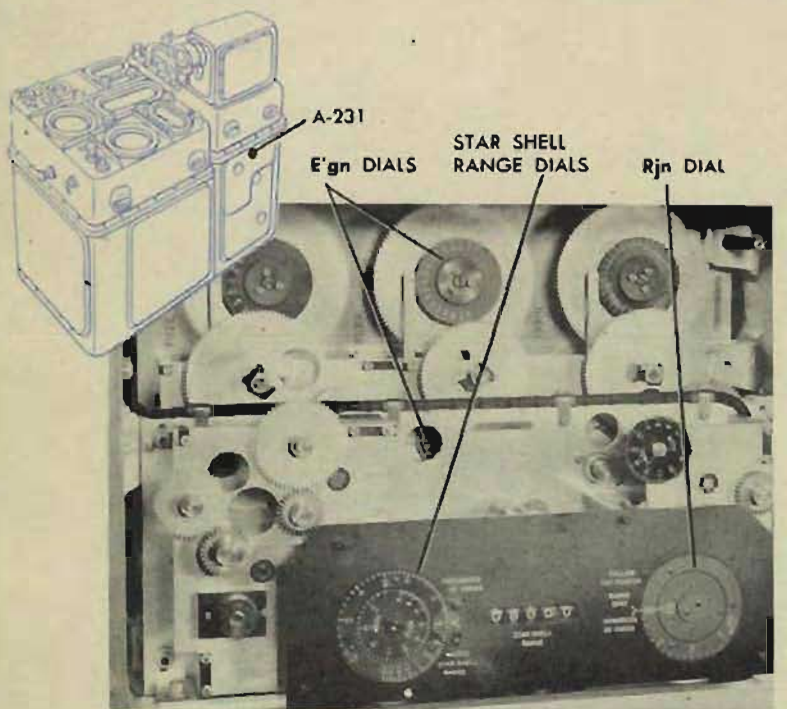
Adjustment

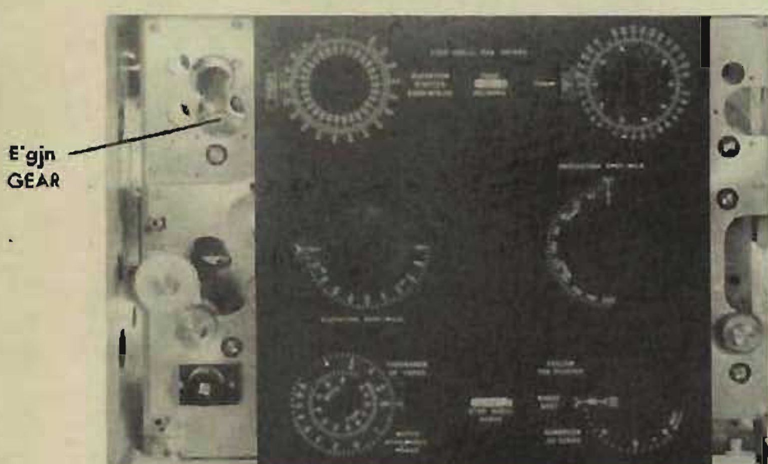
If the counters do not agree, slip-tighten A-230.
Turn the coupling at the rear of A-230 to resynchronize the follow-up until the two counter readings agree.

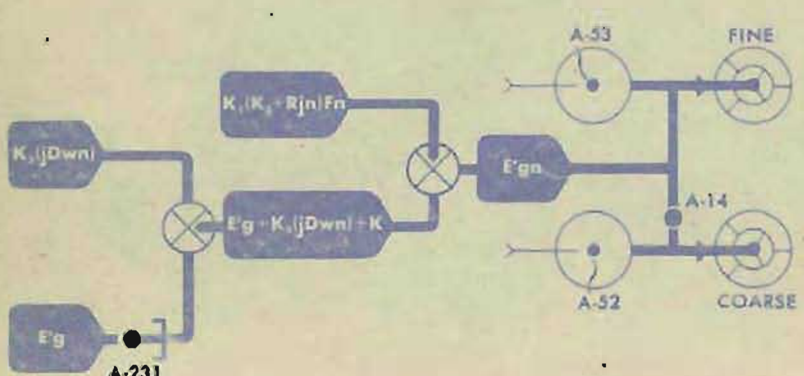
Tighten A-230, and recheck.



A-231 E′gn DIALS to E′g DIALS







MOD 0

Location

A-231 is located under cover 6 in Computer Mark 1.

Check

For mechanical fuze, Mods 0 and 1:
Set both the star shell range ring dial and the fuze range dial at 8,000 yards.
On Mod 1 set *E′jn* at 0.
Set *Rjn* at 0.
The *E′gn* dials (*E′gjn* dials on Mod 1) should read 373′ more than the *E′g* dials.

On Mod 1, check A-22 before readjusting A-231.

For powder fuze, Mod 0:
With the same settings as above, the *E′gn* dials should read 383′ more than the *E′g* dials.

For mechanical fuze, Mod 2:
Set both the star shell range ring dial and the fuze range dial at 10,000 yards.
Set *E′jn* at 0.
Set *Rjn* at 0.
The *E′gjn* dials should read 339′ more than the *E′g* dials.

Check A-22 before readjusting A-231.

Adjustment

If the *E′gn* (or *E′gjn*) dials do not read the correct amount more than the *E′g* dials, loosen A-231.

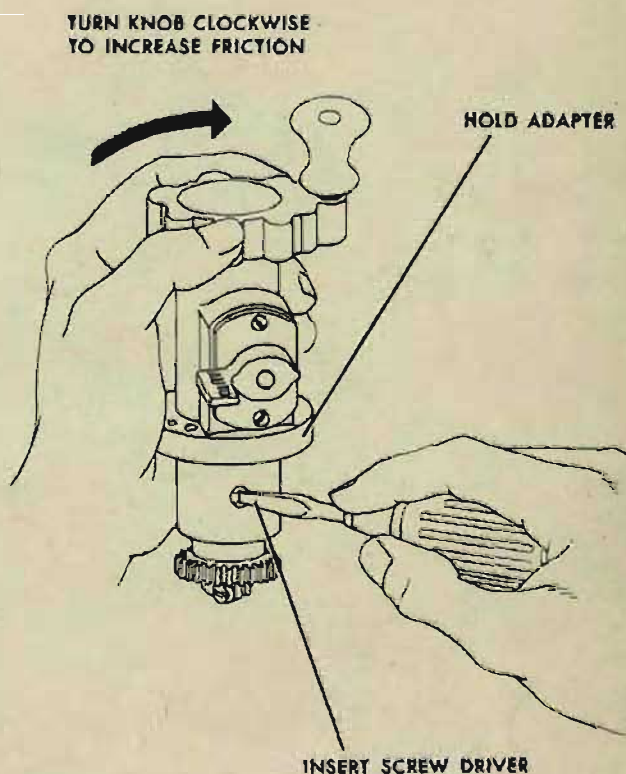
For Mod 0:
Hold the *E′g* line. Turn the *E′gn* gearing until the correct *E′gn* reading is obtained.

For Mods 1 and 2:
Hold the *E′g* and *E′jn* lines. Turn the *E′gjn* input gear until the correct *E′gjn* reading is obtained.

Tighten A-231 and recheck.

HANDCRANKS

The handcranks in the Star Shell Computer Mark 1 have adjustable friction relief drives and holding frictions. The fuze range and the range spot knobs have friction relief drives only. The elevation and the deflection handcranks, not on the Mod 0 instruments, have friction relief drives and holding frictions. Disassembly and repair of a typical handcrank is discussed in OP 1140A.



HOLDING FRICTION

Location

The holding friction is inside the handcrank.

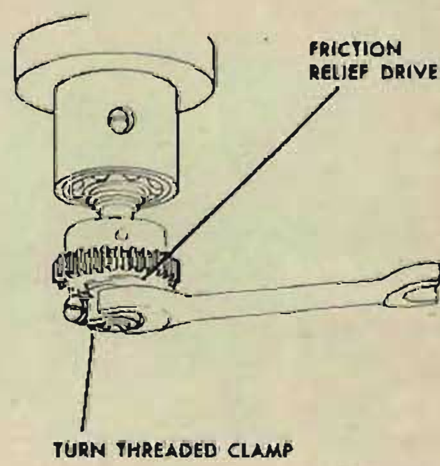
Check

The holding friction should be tight enough to maintain the setting of its quantity under normal operating conditions, yet loose enough for easy operation.

Adjustment

Remove the handcrank from the cover and set it in the outer position. Turn the knob until the adjustment slot appears in the opening; then insert a small screw driver into the slot. Turn the knob clockwise to increase the friction or counterclockwise to decrease the friction.

FRICTION RELIEF DRIVE



Location

The friction relief drive is at the input gear on the end of the handcrank shaft.

Check

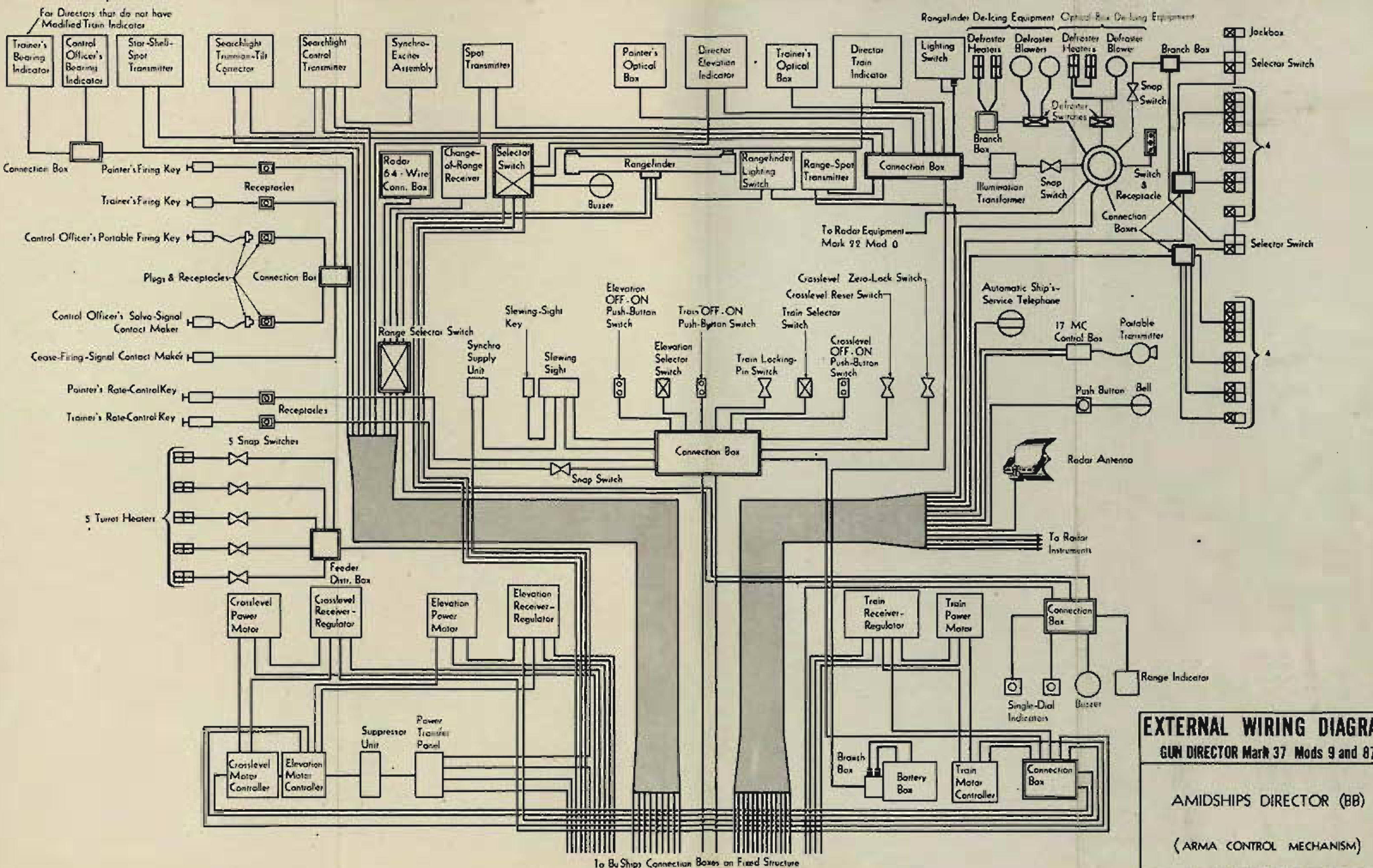
The friction relief drive should be tight enough to drive the line, but loose enough to slip without damaging the shaft line whenever a limit stop is reached.

Adjustment

Loosen the threaded adjustment clamp and turn it clockwise to increase the friction or counterclockwise to decrease the friction. Tighten the clamp.

19.6

20.16



EXTERNAL WIRING DIAGRAM
GUN DIRECTOR Mark 37 Mods 9 and 87

AMIDSHIPS DIRECTOR (BB)

(ARMA CONTROL MECHANISM)

REFERENCE: ORDNANCE DWG. No. 244 117

Fig. 524

RESTRICTED

OP 1064 A
VOLUME 2

COMPUTER MARK 1 AND MODS.

MAINTENANCE

A BUREAU OF ORDNANCE PUBLICATION

VOLUME 2

COMPUTER MARK I AND MODS

MAINTENANCE

This publication is RESTRICTED and will be handled in accordance with Article 76, United States Navy Regulations, 1920.

Gene Slover's US Navy Pages Table of Contents

RESTRICTED

NAVY DEPARTMENT
BUREAU OF ORDNANCE
WASHINGTON 25, D. C.

To all holders of ORDNANCE PAMPHLET 1064A
insert change; write on cover 'Change 1 inserted'
Approved by The Chief of the Bureau of Ordnance

OP 1064A CHANGE 1

5 November 1947

K. H. Noble
Acting Chief of Bureau

1 Page ______ Page 1

Ordnance Pamphlet 1064A
is changed as follows:

COMPUTER MARK 1 AND MODS - MAINTENANCE

Insert attached pages 578 through 583 in place of corresponding blank pages in OP 1064A.

This is Volume Two with pages from 541 to 697
Click on page/subject to go to that page. Click in red blocks to download those pages from the main page

CONTENTS

VOLUME ONE

PART ONE

For Volume One click here to return to main download page

PART TWO

PART THREE

PART FOUR

VOLUME TWO

PART FIVE

PART SIX

PART SEVEN

click here to return to main download page for these pages

PART EIGHT

PART NINE

Part five

LOCATING CASUALTIES

Introduction

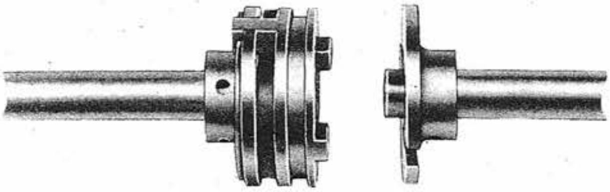
This section deals with various typical casualties, either mechanical or electrical, which may be encountered when the cause of test errors or faulty operation is being traced. The information given here is not intended to be a complete guide for locating all possible sources of trouble, but rather serves as a reference listing of the more common types of trouble. Other information pertaining to trouble analysis is given for various units which are used only in (or with) the Computer Mk 1 and which are not covered elsewhere. This includes a discussion of the special-type follow-ups, disassembly procedure for the range receiver, and the readjustment procedure for the selector drive mechanism.

In order to use this section effectively for locating the source of trouble, it is essential that the maintenance man be thoroughly familiar with the function, construction, and maintenance of all the basic units in OP 1140 and OP 1140A. He will then be able to recognize the units, and typical troubles in the units, as they appear in the computer. Also, after the source of the trouble is located he will be able to decide how to accomplish the actual repair of a casualty.

In general, the method given for locating the source of each type of trouble consists of performing mechanical or electrical checks upon a unit while it is in the instrument until the exact cause of the trouble has been isolated. The nature of the trouble will then determine whether the unit must be removed for repair on the bench.

OLDHAM COUPLINGS

The following list of Oldham couplings, with their values per revolution and their connection in the gear train, may be used in the analysis of test errors. Extreme shock sometimes causes temporary disengagement of Oldham couplings, permitting a line to become out of adjustment any number of *half*-revolutions of the shaft. When a unit or line is found to be improperly positioned in relation to another unit or line, check the Oldham coupling list. If the difference in position is equal to some number of half-revolutions of the coupling in that line, the readjustment may be effected by breaking the coupling and turning the shaft the proper amount, then remaking the coupling.



Although an attempt has been made to list the adjustments which will be affected in the event an Oldham coupling has become temporarily disengaged and repositioned, the gearing diagram should always be consulted to establish the exact location of the coupling and the units affected by it. Never try to analyze a gearing or Oldham coupling casualty by use of the schematic. Only the gearing diagram shows the exact relationship between the various shaft lines and units. Where no adjustment number is listed, no readjustment of that shaft line is necessary.

Oldham Couplings

CONNECTS	TO	VALUE/REV.	ADJ. NO.	SHAFT NO.
Target Angle Dial	Target Component Solver	10°	532 136	43-S108 43-S42
Br	*Br* Dials	1.25°	199	43-S198
Br	*Br* Dials	1.25°	199	43-S226 43-S123
cBr	Local Control Follow-up	1.25°	70	3-S34 43-S220
cBr	Local Control Follow-up	1.25°	70	3-S29 3-S5
cB'r	Local Control Follow-up	2.5°	70	40-B79 12-E6
$\triangle cBr$	Rate Control Section	1°		44-S60
B'r	Deck Tilt Computer and A-199	1.5°	99	14-A21 40-B38
jB'r	D-79 ($\triangle cBr - jB'r = \triangle cB'r$)	0.5°		3-S28 3-S4
B'gr or *B'r*	Parallax Computer	2.5°	243	14-A18 3-S14
B'gr or *B'r*	Parallax Computer	15°	243	3-S16 47-S7
B'gr	Star Shell Computer	2°	S. S. 17	14-A24
B'gr	Star Shell Computer	2°	S. S. 17	41-S69 41-S76
B'gr	Star Shell Computer	2.5°	S. S. 17	14-C7
Bws Dial	Horizontal Wind Component Solver	2.5°	105	49-S2
Co Receiver	*Co* Dials	1.5°	179	44-S61
Dd	D-15 ($B'r + Dd = B'gr$)	0.72°	99, 98, 602	40-B50 14-A9
Dip Dial	Sync *E*	1.25°	91	40-E8 41-S54
Dj Dial	L-30	1.5 mils	500, 86	14-A1
Dj Dial	L-30	3 mils	500, 86	14-A3 40-B52
Dj Dial	L-30	6 mils	500, 86	43-S187
Ds Ind. Counter	*Ds* Master Counter	20 mils	89	41-S34 40-A26
Ds Counter	L-28	20 mils	198	43-S200
Ds Counter	L-28	20 mils	198	49-S25

Oldham Couplings

CONNECTS	TO	VALUE/REV.	ADJ. NO.	SHAFT NO.
E	dH Component Solver	22.5°	123	43-S93 43-S102
E Dials	L-12	1.25°	116	3-S30 3-S25
E	D-73 ($E + V = E2$)	1.25°	180	49-S29
E	Sec E Cam and A-180	1.25°	260	44-S64
Sync E CENTER Position Gear	E	1.25°		40-E6 41-S44
Sync E Dials	D-12	1.25°	90	41-S47 40-E4
$E2$ Intermittent Drive	Ballistic Computers	1.5°	71, 72, 73, 84, 85	48-S27 7-D2
$E2$ Matching Counter	$E2$ Master Counter	1.5°	183	49-S30
$E2 + L$	Parallax Computer	5°	3, 227	40-D11 47-S8
$\triangle cE$	Rate Control	20 min.		44-S58
Eb	L-11	2°	50, 51	40-D31 14-B8
$Eb + Vs$	Trunnion Tilt Computer	2°	61 32	40-D37 40-E18
$E'g$	Star Shell Computer	150 min.	231	14-B25
$E'g$	Star Shell Computer	150 min.	231	14-C6
F Ind. Counter	F Master Counter	1 sec.	77	3-S27
F Ind. Counter	F Master Counter	1 sec.	77	40-B56 41-S30
$F - Tf$ (Ser. Nos. 781 and higher)	D-89 ($Tg + F - Tf$)	2 sec.	262	45-B21 45-D16
$L + \frac{Zd}{30}$	$L + \frac{Zd}{30}$	3°		44-S65
cR	Height Computer	388.9 yds.	138	43-S96 43-S97
cR	L-10	200 yds.	196	49-S12
cR	cR Intermittent Drive	200 yds.	233	44-S63
$1/cR$	$1/cR$ Integrator		149	44-S44 44-S45
dR Follow-up	Range Integrator and dR Dial	5.5π kn.	163, 171 132, 181	43-S143 43-S142

Gene Slover's US Navy Pages | Table of Contents

Oldham Couplings

CONNECTS	TO	VALUE/REV.	ADJ. NO.	SHAFT NO.
dR	dRs	20π kn.	181, 132	49-S17
dR (Ser. Nos. 780 and lower)	Dead Time Prediction Multiplier	20π kn.	132	7-D23 45-A27
dRs	Range Prediction Multiplier (all) Dead Time Prediction Multiplier (Ser. Nos. 781 and higher)	19π kn.	135 132	45-A28 46-A36
$R2$	Ballistic Computers except Fuze	600 yds.	74, 75 76	46-B22 48-S26
$R2$	$R2$ in Rear Units	600 yds.	156	3-S33
$R2$	$R2$ Ind. Counter $R2$ to Star Shell	600 yds.	92 S. S. 18	3-S12 14-A8
$R2$	$R2$ Ind. Counter $R2$ to Star Shell	800 yds.	92 S. S. 18	14-A4
$R2$	Star Shell	800 yds.	S. S. 18	41-S63
$R2$	Star Shell	400 yds.	S. S. 18	14-G4
$R2$	Parallax	550 yds.	156, 92, S. S. 18	47-S5 3-S13
Rj	L-29	33⅓ yds.	234, 235, 88	41-S23 40-B53
Rj	L-29	33⅓ yds.	234, 235, 88	43-S189
Rj	L-29	60 yds.	234, 235, 88	49-S16
$RdBs$	Range Rate Corrector	20π kn.	109	49-S19
$RdBs$	Bearing Integrator	20π kn.	139	49-S28
RdE	Range Rate Corrector	20π kn.	108	49-S18
RdE	Elevation Integrator	20π kn.	154	44-S59
So Receiver	So Dial	2 kn.	212	41-S60 40-E22
So Receiver	So Dial	2.25 kn.	212	43-S238
Sw Dial	Horizontal Wind Component Solver	3 kn.	157	49-S4
Sec E	Sec E Integrator		147	44-S42 44-S43
Tf (Ser. Nos. 781 and higher)	D-90 $(F - Tf)$	1.25 sec.	262	45-B20 48-S32
$Tg + F - Tf$	Dead Time Prediction Multiplier	5 sec.	188	49-S27 45-D15

Oldham Couplings

CONNECTS	TO	VALUE/REV.	ADJ. NO.	SHAFT NO.
Time	Time	1216.67 rpm		44-S62
Vj	L-31	1.5 mils	501 87	41-S14 40-B61
Vj Dials	L-31	6 mils	501, 87	49-S9
Vj Dials	L-31	6 mils	501, 87	43-S196
Vs Counter	L-37	30 min.	184	49-S31
Vs Counter	L-37	30 min.	184	44-S47 44-S48
Vs Counter	L-37	30 min.	184	44-S46 40-D58
Vs Ind. Counter	*Vs* Master Counter	30 min.	55	40-E10 41-S43
Vs Ind. Counter	*Vs* Master Counter	30 min.	184, 55, 51	40-D35 14-B4
Vz Dials	L-34	25/8°	29 51	L-34 40-B77
Vz Dials	L-34	25/8°	29 51	40-B78 40-D62
Vz Dials	*E'g* Dials	2°	51	40-D61 14-B6
S. S. Defl. Counter	S. S. Defl. Follow-up	20π kn.	230	45-A32 49-S34
S. S. Defl. Follow-up	Star Shell Computer	5π kn.	230	3-S42
S. S. Defl. Follow-up	Star Shell Computer	5π kn.	230	40-B82 41-S71
S. S. Defl. Follow-up	Star Shell Computer	5π kn.	230	14-C5
Xo	D-53 ($Xo + Xwg = WrD$)	8π kn.	131	49-S22
Yo	D-54 ($Yo + Ywg = Ywgr$)	4π kn.	101	49-S21
Ywgr	Elevation Wind Component Solver	1.25 kn.	100	49-S3
Zd Dials	Trunnion Tilt Computer	3°	112	40-B22 40-C18
Zd Dials	Deck Tilt Computer	1.5°	111	40-C8 40-D19
Zd^2	*jDd* Computer	8.75°	34	40-C5 40-B4

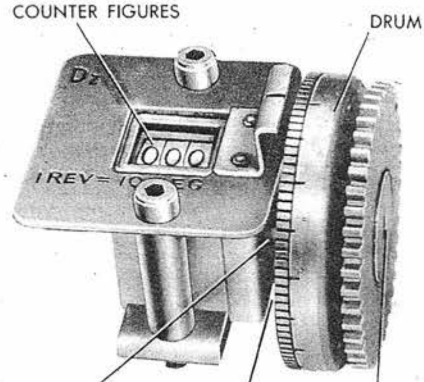
Gene Slover's US Navy Pages

Table of Contents

COUNTERS

The small test counters used in the instrument may freeze. Usually, they will bind first and thus cause sluggishness in the associated line. If the binding is allowed to continue so that the counter shaft freezes in its housing, the counter drum clamp will slip, the shaft will break, or the line will stall. In any case the counter will remain at a fixed value.

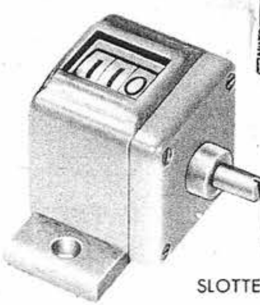
A binding counter may be detected by feeling the counter drum shaft for end play. If the end play is not perfectly free, or if none can be felt, the counter shaft is probably binding.



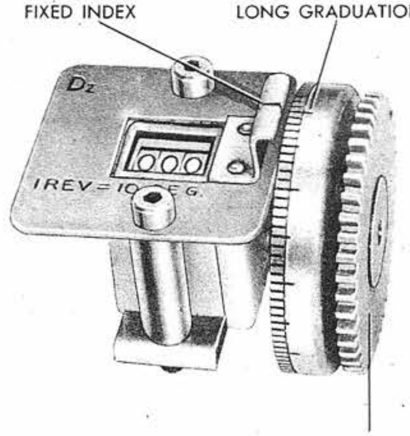
TEST COUNTER

When a faulty counter is replaced, it is usually necessary only to readjust the new counter to the line, using the adjustment clamp adjacent to the counter. In some cases, however, no adjustment clamp is available, so the counter gear mesh must be used for adjustment.

Before installing a new counter, the counter drum should first be set on the shaft of the new counter so that one of the longest graduations matches the fixed index when the counter figures are centered. While the drum is held the figures may be centered by turning the slotted shaft of the counter with a small screw driver. Then the clamp on the drum hub should be tightened. The drum must clear the fixed index plate.



When the gear mesh must be used for readjustment, special precautions will save trouble. First, set the line on a whole number value so that a long drum graduation matches the fixed index of the counter. Mark this graduation, and mark the drum gear mesh. Remove the counter. Install the drum on the new counter. Using the marked drum graduation, set the new counter at the established value of the line. Replace the counter so that the marked gear teeth are matched.

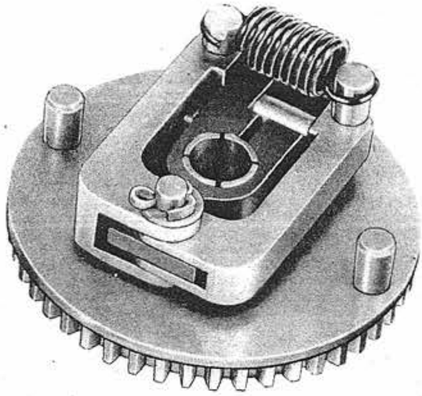


Whenever a counter is re-installed in the computer, make sure that its gear mesh has sufficient play. The small counter shaft cannot withstand side-loading due to a tight gear mesh.

The binding or freezing of a counter may have caused a clamp in the line to slip, thereby upsetting the adjustment of other units. This possibility should always be considered, and reference made to the schematic diagram to analyze the effects.

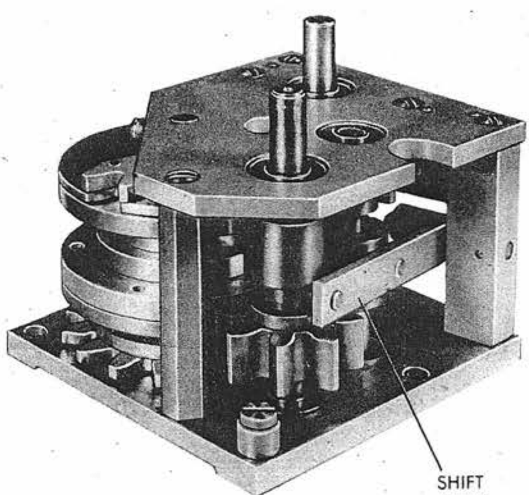
INTERMITTENT DRIVES

Intermittent drives occasionally cause trouble in the computer. Possible casualties are binding of the shock-absorber assembly and jamming at the cut-out point.



SHOCK-ABSORBER ASSEMBLY

If the output of an intermittent drive does not agree with the input value when the drive is cut in, check the shock-absorber assembly. Try turning the output line in the direction toward agreement with the input value. If the line "gives" and falls into agreement, the indication is that the shock-absorber assembly had stuck open. Hold the input and turn the output to open the shock-absorber assembly in either direction. Releasing the output line should permit the shock absorber to close. If it fails to close, the binding may be in either the shock-absorber assembly itself or in the output line. Open the clamps in the output line to isolate the binding. If opening a clamp frees the shock absorber, the trouble is beyond the point opened. If the binding persists, it is in the shock-absorber assembly.



If a line jams, and the line has an intermittent drive, the cause may be that the drive has jammed at a cut-out point. Check whether the line is at a cut-out value. If it is, the intermittent drive is probably causing the trouble. Check whether pushing on the shift lever releases the jamming. If it does, the shift mechanism is out of adjustment.

If the shock absorber binds or if the drive jams at the cut-out point, remove the faulty unit; see the chapters on *Removal of Mechanisms* in this OP. See OP 1140A for repair of the unit.

SOLENOID LOCKS AND CLUTCHES

Solenoid locks and clutches are used in the rate control section of the computer. The locks hold lines which are not used during SEMI-AUTO and LOCAL control. If a lock fails to hold, part of the generated quantity may back out through that line. The clutches connect the AUTO rate control lines to the rate control computing mechanism. If a clutch fails, the AUTO rate correction is not fed into the rate control mechanism.

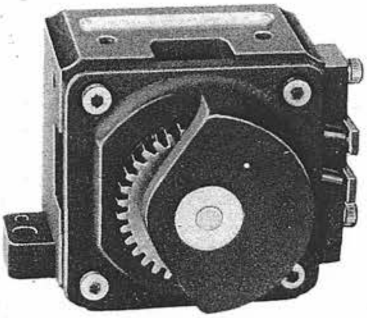
Although a noisy lock or clutch is not desirable, it is not strictly a casualty unless the chatter is sufficient to cause the connecting teeth to disengage partially.

A lock may fail to close or the holding pin in the lock may shear off. If a lock is not holding, the solution indicator will turn during B tests. If the lock fails to close, the solution indicator will turn freely. If the pin has sheared, the solution indicator may turn only occasionally during a high rate B test problem. See *Removal of Mechanisms*, pages 613 and 616, for instructions on removing the unit and see OP 1140A for its repair.

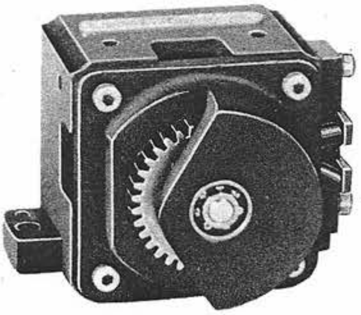
A lock which fails to hold has no effect on satisfactory operation of the computer in AUTO control.

If a lock should fail to open, that is, stick closed after being de-energized, AUTO rate control would not function. However, the torque on the line usually will cause the lock to disengage so that normal operation is not hindered. If a lock is suspected of sticking, shift the control switch between AUTO and SEMI-AUTO several times. The lock should be heard to engage every time the switch is turned to SEMI-AUTO. This check should be repeated with cover 1 removed to make sure that the lock is faulty before removing the unit.

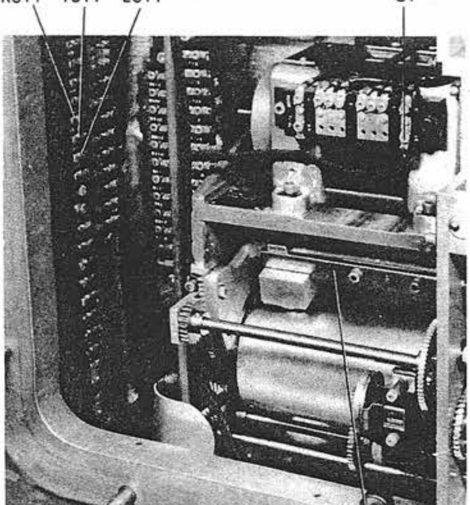
SOLENOID LOCK



SOLENOID CLUTCH



Gene Slover's US Navy Pages | Table of Contents



The clutches are energized by signal keys in the director when the control switch is at AUTO. Remember that range has a separate control switch. When the switch is at AUTO, the range clutch is energized by the range signal from the director; when the switch is at MANUAL, the clutch is energized by the RANGE RATE CONTROL MANUAL push-button. The closing of a clutch may be heard as its signal key is closed. Placing the ear against the computer case near a clutch will make its closing more easily heard. The signal key circuit may be by-passed by using a jumper as follows:

1 Remove cover 4.

2 Secure one end of a two-foot jumper to terminal C1 of the *Vf + Pe* ballistic computer. NOTE: Care should be exercised in handling the other, exposed, end of the jumper.

3 Touch the other end of the jumper to the terminal of the circuit in question—
   RS11 for the range signal
   TS11 for the train signal
   ES11 for the elevation signal

4 The corresponding clutch should be heard to close each time the jumper is touched to the terminal.

5 Remove the jumper when the check is completed.

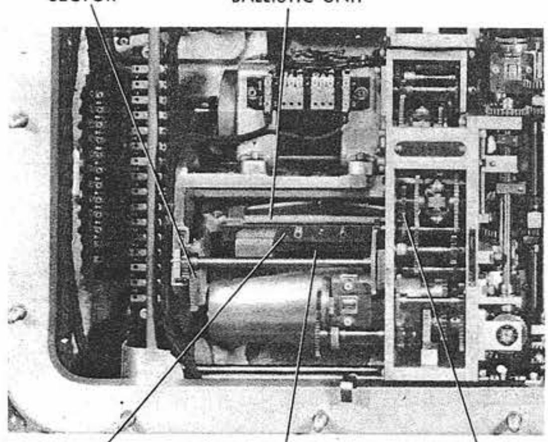
If a clutch is not heard to close when the circuit is completed, remove cover 1 and repeat the check to make sure that the clutch is inoperative before removing it.

While testing a clutch, it may stay closed after the circuit is broken. Usually, a slight pressure on the line, as in normal operation, will release the clutch. If the clutch sticks, however, it should be removed and repaired. See OP 1140A and *Removal of Mechanisms* in this OP.

BALLISTIC COMPUTERS

The four ballistic computer units are similar in construction and operation, and are subject, therefore, to similar types of casualties.

Since each unit contains three test counters which may operate at relatively high speed, the chance of a counter casualty occurring in these units is increased. The *E2* counters in particular, since they rotate rapidly every time the *E* line is slewed by the director, may become casualties due to binding or freezing. This will result in sluggish operation of the *E2* line, and in some cases the *Eb* receiver motors will be stalled. Therefore, if any of the lines in the ballistic computers are sluggish or excessively heavy, the counters should be checked for casualties. Refer to page 551.



Since *E2* also drives the lead screw of each ballistic computer, any binding of the lead screw will also overload the *E2* and *Eb* lines. Binding may be detected by opening the clamp which connects the main *E2* line with a particular ballistic unit, and then turning the lead-screw input gear through its full travel. Binding may be caused by a combination of dirt and lack of lubrication on the lead screw. In such a case, the screw may be cleaned with approved solvent and re-lubricated without removing the unit. If the binding still exists, or if the lead-screw threads are damaged, the unit should be removed and repaired. Refer to *Removal of Mechanisms* in this OP and to OP 1140A.

Each ballistic cam output is mechanically amplified by gearing before it reaches its follow-up control. This means that the cam follower works at a mechanical disadvantage with respect to the follow-up control gearing. Therefore, the entire gear train between cam follower and follow-up must be kept perfectly free. Otherwise, the cam follower will be greatly overloaded by a slight stick in the gearing. As a consequence, the *E2* line would be overloaded in trying to move the cam follower. This condition would show up as a sluggish *E2* line; or, in the course of running tests, the cam follower might "hang up" to such an extent that the cam-follower springs could no longer hold the follower rail against the follower ball, resulting in large test errors. This load condition is particularly likely in the $Vf + Pe$ ballistic computer, which has a very large gear ratio between the cam follower and follow-up. It should be noted that the lever-arm spring in the $Vf + Pe$ follow-up is made very light in order to reduce the load on the cam follower.

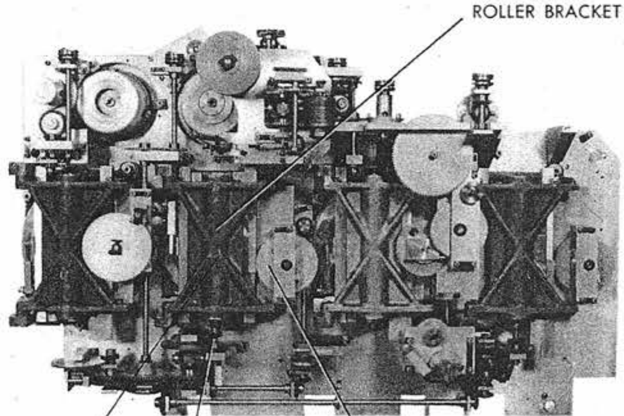
To check the cam output gearing for excessive load or sticks, move the follower sector gear so as to lift the follower rail from the ball, with the ballistic computer follow-up energized. The line should feel perfectly free and should drive the follow-up smoothly. Gently lower the follower rail until it touches the ball. It should return to position easily and positively. If any excessive load, roughness, or sticking exists, the trouble may be in the cam output gearing or shaft lines, or in the follow-up control. For repair of these parts, refer to *The Ballistic Computer* and *The Follow-up* in OP 1140A.

Gene Slover's US Navy Pages | Table of Contents

INTEGRATORS

The existence of integrator trouble is usually indicated by an analysis of test errors or by unit check tests performed on the generating mechanism. If an integrator is suspected of giving an erratic, rough, or inconsistent output, certain checks may be made with the unit in place.

INTEGRATOR UNIT
REMOVED FROM COMPUTER



The integrator being checked should first be isolated from the load of its output line by disconnecting its output gear or coupling. Then, position the carriage input so that the integrator output is zero. Observe the output while the plate is rotated. If the zero point is not maintained, the eccentric stud which supports the integrator plate may be loose. This casualty may be repaired only after the entire integrator has been removed.

Check the freeness of the carriage travel by lifting the carriage manually as far as the lost motion of the line will permit. When the carriage is released, it should return to the exact position it had previously. The zero point may be used initially for this check. The check should then be repeated at several other positions of the carriage on both sides of the zero point. To check the exact repositioning of the carriage at points other than zero, connect the integrator output temporarily and run either a B test or an integrator timing test several times at the selected position. Consistent results in a test will indicate that the carriage is returning to the same position each time it is raised and released.

 Table of Contents

If the carriage does not return properly, there may be sticking or binding in the carriage itself, or in its input line. The carriage may be isolated from the line by removing the carriage input gearing. The carriage should then be checked for sticking or binding throughout its entire travel.

Check the freeness of the output roller by turning it manually with the integrator roller bracket slightly raised against the spring tension. If any sticks are felt, the roller supporting bearings are probably dirty.

Check the surface of the plate, balls, and output roller for dirt, nicks, or rust. Any of these may cause rough or erratic output.

If dirt or chips are found in the unit, the parts should be cleaned with an approved solvent, and re-lubricated. If this does not eliminate the sticking or binding, the integrator should be removed and overhauled. Refer to *Removal of Mechanisms* in this OP and to OP 1140A.

Gene Slover's US Navy Pages
Table of Contents

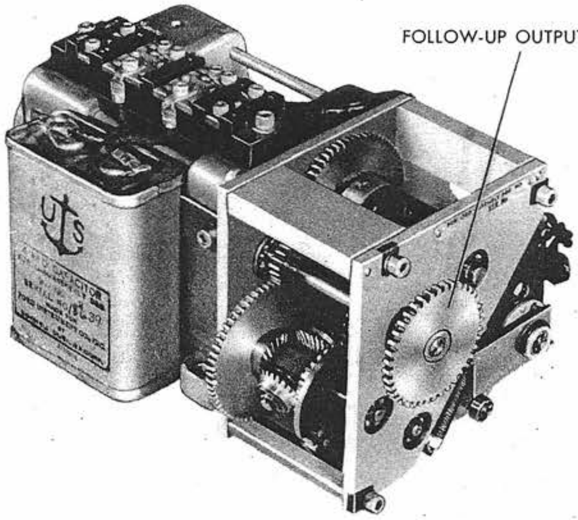
FOLLOW-UPS

Whenever a line is in error the follow-up involved should be checked. The follow-up output should be observed as it drives to synchronization from either direction, and the point of synchronization should be noted each time. If the line has a handcrank, the follow-up may be driven off synchronization by turning the handcrank in the IN position. Other follow-ups may be driven off manually with computer power OFF.

The synchronization point is usually read on a dial or counter. The follow-ups which do not drive a dial or counter may be checked by placing matching pencil marks on an output gear and an adjacent plate. If the follow-up is operating satisfactorily, it should return to the same synchronization point, with the same action, from either direction of offset. If the synchronization point is broad, or the action is sluggish in either direction, the follow-up should be carefully checked to locate the source of trouble.

The various troubles and casualties pertaining to follow-ups are discussed in OP 1140A.

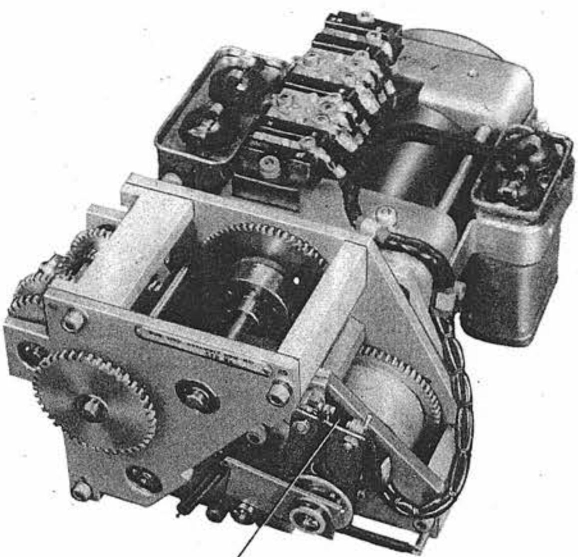
TYPICAL FOLLOW-UP

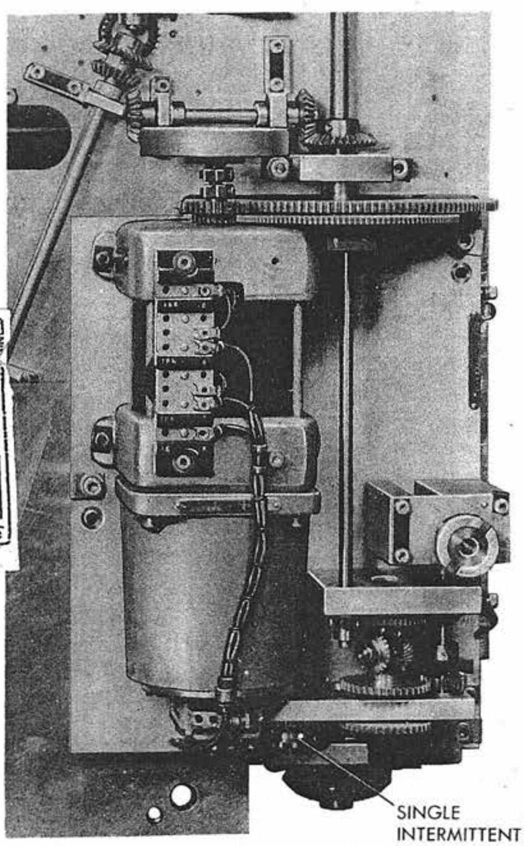


Gene Slover's US Navy Pages

Table of Contents

COARSE FOLLOW-UP





cB′r FOLLOW-UP

The input lines to follow-ups usually contain lost motion. Where the lost motion is considerable, take-up springs are used. Any restriction in the input line will cause this lost motion to "hang up," causing an output error. The freeness of the line may be checked by manually offsetting the follow-up input gear in either direction. The follow-up should resynchronize to the original output reading when the line is released. A common source of trouble is a tight mesh between the follow-up input gear and the mating gear on the input line. Most follow-ups are mounted by screws in the motor feet. If these screws are not sufficiently tight, severe shock may move the unit and cause it to be incorrectly aligned for a proper gear mesh. During normal operation, the follow-up affected would produce a rough output; during static tests it would show an error in the output due to "hanging-up" of the input line.

Follow-ups used in the Computer Mk 1 which differ from the standard type discussed in OP1140A are:

The *jE* and *jBr* (coarse) follow-ups

The *cB′r* (local control) follow-up

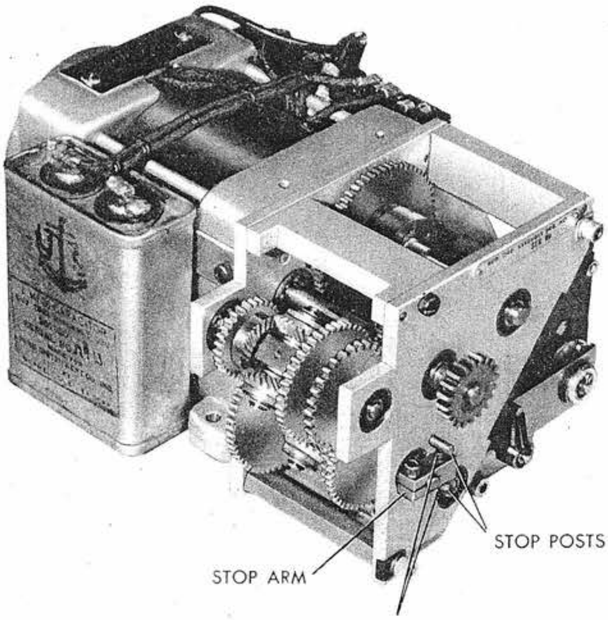
The *Sh* and *Ct* (limited) follow-ups

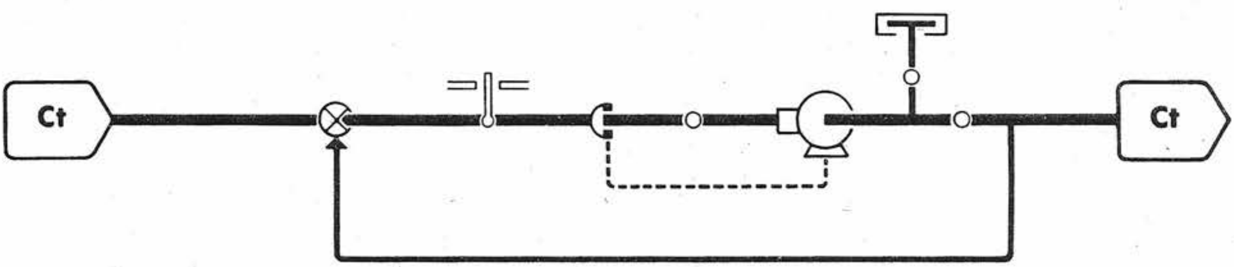
The *jE* and the *jBr* follow-ups are of a special type and are energized only during automatic rate control. They differ in two respects from a standard follow-up. The contacts are widely spaced, and the intermittent gearing has only one locking disk. The wide contact gap causes about 15 min. total dead space in the *jBr* follow-up output and about 8 min. in *jE*.

The *cB′r* follow-up differs from the standard compensated type in its intermittent gearing. It has only one intermittent gear instead of the usual two.

The *Sh* and *Ct* follow-ups are the limited type. They differ from the standard velocity-lag follow-up in that they have no intermittent gearing in which to store up a large error or difference between input and output. Also, the contact movement is limited to small amounts by a stop arm and post assembly. A neoprene buffer on either side of the arm bears against a stop post when either limit is reached.

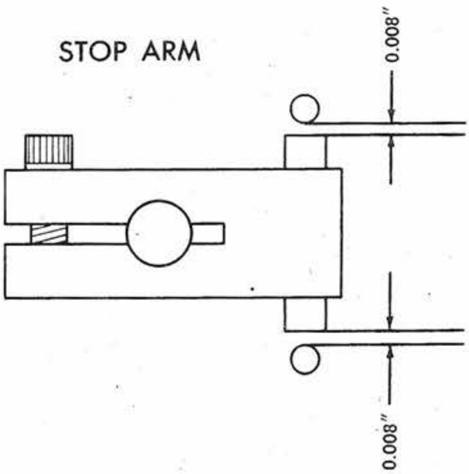
LIMITED FOLLOW-UP



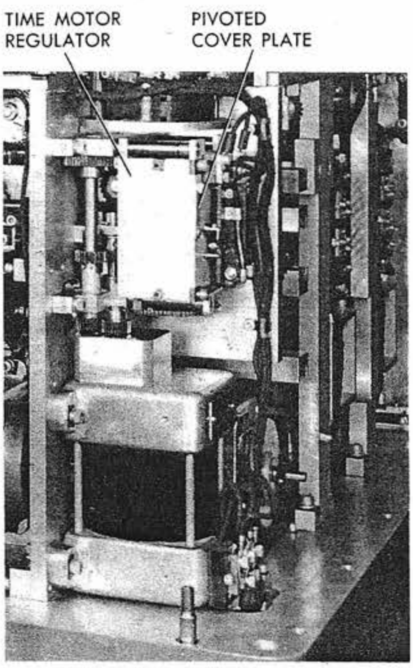


The space between each buffer and its stop post should be about 0.008 inch when the follow-up is synchronized. If the space is too small, the follow-up will drive too slowly. If the total space between the buffers and the stop posts is 0.016 inch, but the space is not centered when the follow-up is synchronized, the indication is that the center contact arm is bent. If the buffer spacing and centering is correct, but the follow-up contact gap is too large, the effect will again be to reduce the maximum motor speed. The total contact gap should be 0.008 inch to 0.010 inch.

STOP ARM



THE TIME MOTOR REGULATOR



The functional description and operation of the time motor regulator are covered in OP 1140.

If the results of the time motor regulator test indicate excessive errors, an attempt should be made to adjust the regulator in place. Remove cover 1, or on later instruments remove the plate at the right front of cover 1, to gain access to the regulator. Near the contact arms is a small pivoted cover plate. Loosen the screw at the top, and swing the plate toward the front. Access may then be had to the regulator lever. Move the lever slightly toward F if the time line was running too slowly, or toward S if the time line was running too fast.

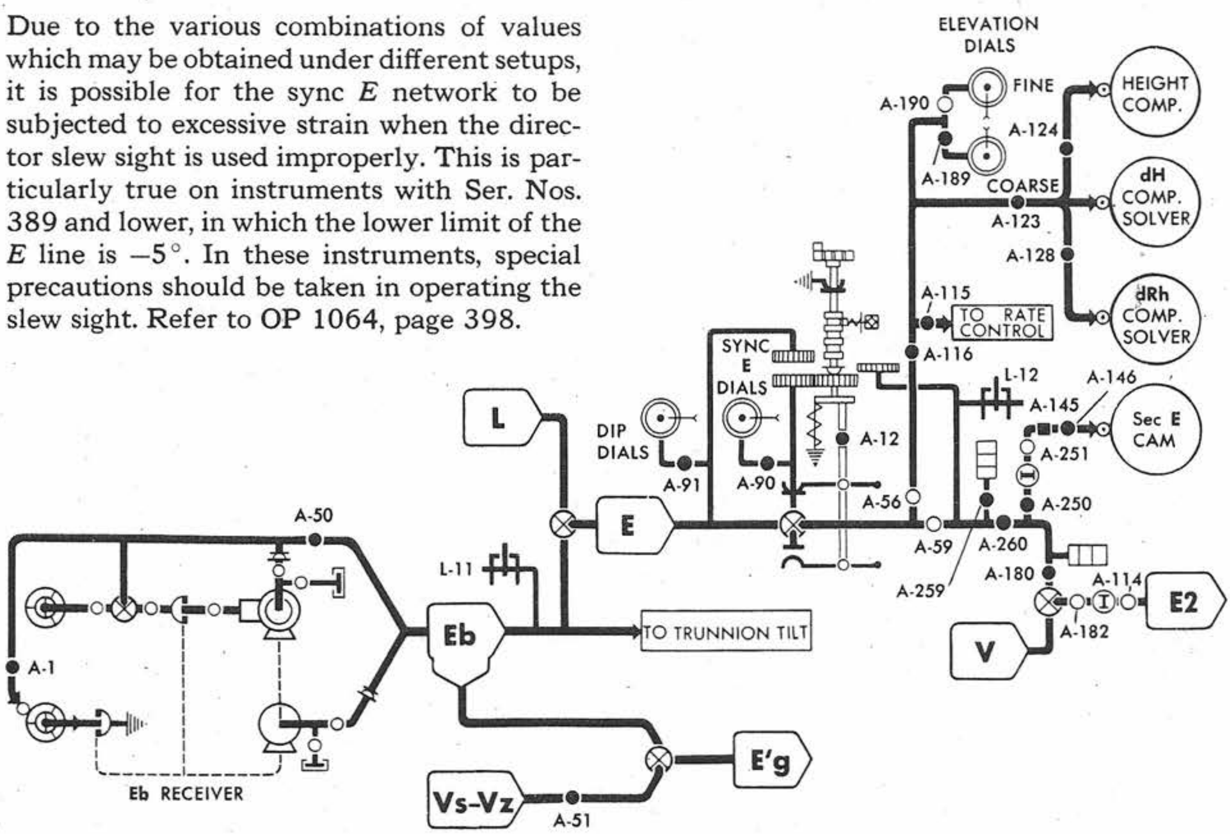
Run the test again. If the error is still excessive repeat the adjustment as necessary.

If moving the lever to the limit of its travel in either direction does not produce the desired results, and the voltage and frequency have been maintained within specified limits, then the trouble may be in some part of the regulator, in the time motor, or in the time shaft lines. If the time line is running excessively fast, the trouble is usually in the regulator. Try adjusting the main spring. See OP 1140, page 216. If this is not successful, remove the regulator from the instrument. See page 603 in this OP. Replace the escapement mechanism. See OP 1140A. If no replacement is available, it may be possible for an experienced man to adjust the hairspring tension in order to make the regulator lever operative. See OP 1140, page 217. If the time line is running excessively slow, the trouble may be due to sticking or binding in the time motor reduction gear or the time shaft lines. Refer to pages 92 and 432 in OP 1140A for the procedure used in checking and repairing these parts.

Gene Slover's US Navy Pages
Table of Contents

SYNCHRONIZE ELEVATION NETWORK

Due to the various combinations of values which may be obtained under different setups, it is possible for the sync *E* network to be subjected to excessive strain when the director slew sight is used improperly. This is particularly true on instruments with Ser. Nos. 389 and lower, in which the lower limit of the *E* line is –5°. In these instruments, special precautions should be taken in operating the slew sight. Refer to OP 1064, page 398.



The usual cause of excessive strain is slewing the *E* line into either limit of L-12. Since there are several units on the *E* line which have considerable inertia, the sudden stop may cause slippage at adjustment or assembly clamps, or it may cause a casualty in the gear train.

If the sync *E* network has been subjected to extreme shock, the entire network should always be given a systematic check as follows:

> Put the sync *E* handcrank IN and match the sync *E* dials at the fixed index.
>
> Set *L* and *Vs* at 2000′, and *Vz* at 0′. Transmit a value of *Eb* from the director.
>
> The readings of the *E* dials and the *E′g* dials should agree with the value being transmitted. To convert degrees of *Eb* to minutes of *E′g*, multiply by 60 and add 2000.

If both dial readings are in error by an equal amount, either A-50 has slipped, or there is a casualty in that part of the gear train.

If only the *E* dials are in error, either A-116 or A-56 has slipped, or there is a casualty in the *E* line to the control unit. On instruments with Ser. Nos. 291 and higher, A-56 and A-59 are of a type which will not slip when properly assembled.

If the *E* dials read correctly, put the sync *E* handcrank at CENTER and check the values of L-12. If they are incorrect, either A-59 or a gear in the line has slipped.

If the values of L-12 are correct, check the vector gear positions of the *dH* and *dRh* component solvers, and the height computer. Refer to *Unit Check Tests*, pages 192 and 197. If all three vector gears are in error by the same amount, either A-123 or a gear in the line has slipped.

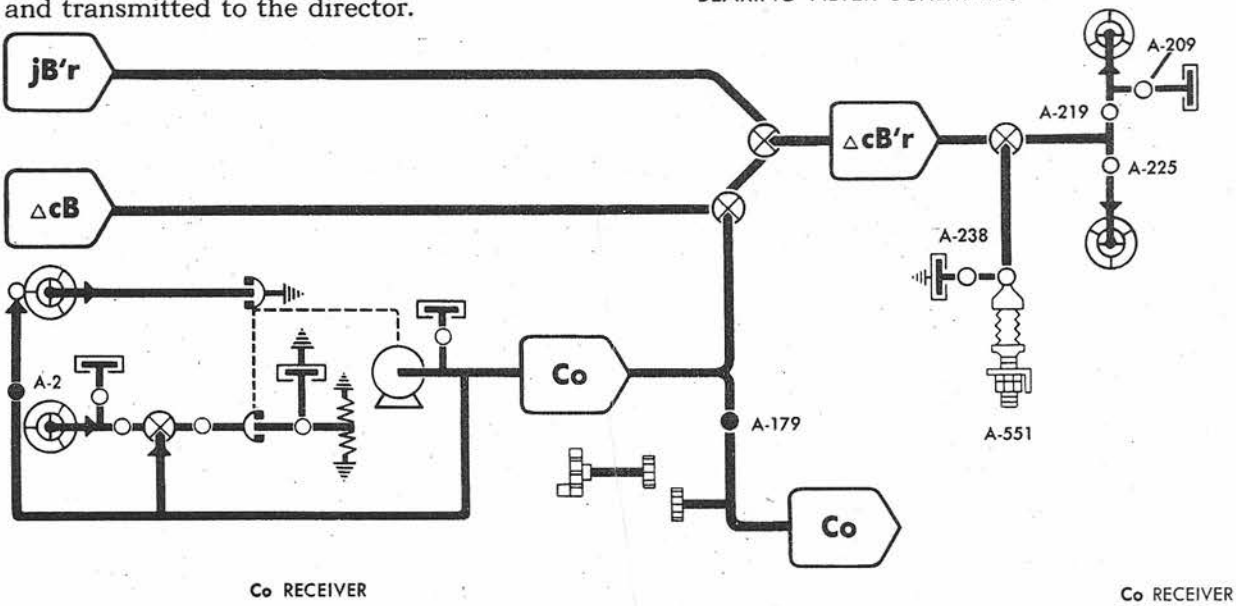
The lines which have intermittent drives rarely cause trouble by slippage. If they do, the intermittent-drive shock absorber is probably faulty. On instruments with Ser. Nos. 389 and lower, there is no intermittent drive on the *E* line to the sec *E* cam. This line, therefore, is susceptible to shock. A-210 may slip and upset the sec *E* cam. Refer to the check of A-210. See *Readjustment Procedure,* page 443.

If any part of the sync *E* network is found in error after sudden shock, no readjustment should be made until the line involved is carefully checked to make sure it is free from casualties. Possible casualties are a sheared taper pin in a gear or coupling hub, slippage of a gear on its inserted hub, or a damaged limit stop. If no casualties are found, check each adjustment on the line in accordance with *Readjustment Procedure*.

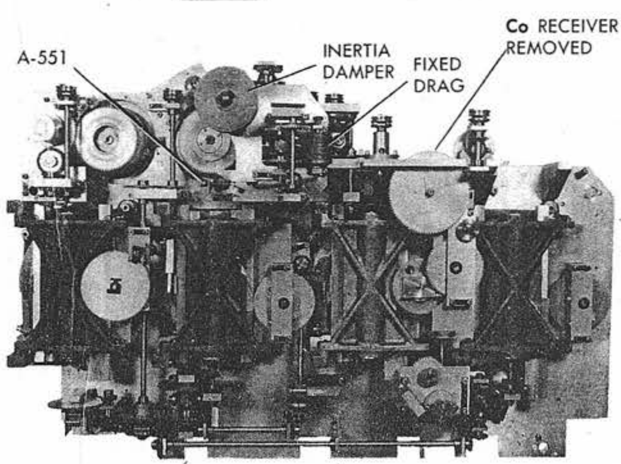
BEARING FILTER

The purpose of the bearing filter in Computer Mk 1 is to prevent roughness or oscillations in the *Co* input signal from being amplified and transmitted to the director.

BEARING FILTER SCHEMATIC

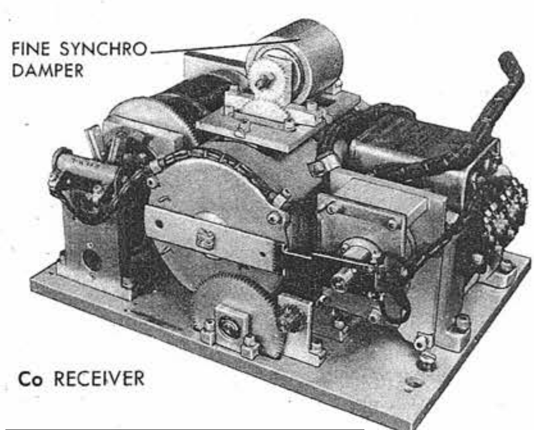


If the △*cB'r* output from the computer seems excessively rough, or contains excessive oscillation, the trouble may be in the bearing filter. The generated bearing line, however, should be checked first. Put the *Co* handcrank IN. Set up the computer to generate a slow bearing rate, and observe the generated bearing output. If it is rough, the trouble may be due to tightness, dirt, or sticking in the integrators or shaft lines associated with generated bearing. Refer to OP 1140A for instructions on checking these parts.

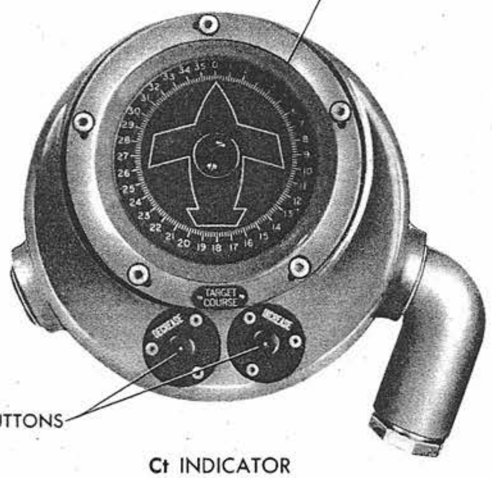


INTEGRATOR UNIT (REMOVED FROM COMPUTER)

If the trouble still exists, the bearing filter system may be at fault. Check the spring tension adjustment, A-551. Check the fixed magnetic drag, the large inertia damper, and the fine synchro damper on top of the *Co* receiver to see that these units have not been demagnetized and that they are free from internal sticks. Check the *Co* receiver itself. Refer to *Magnetic Dampers,* and *Synchro Receivers,* OP 1140A. Check the △*cB'r* and *Co* lines, to make sure that they are free from tight gear meshes, binding shafts, or sticky bearings.



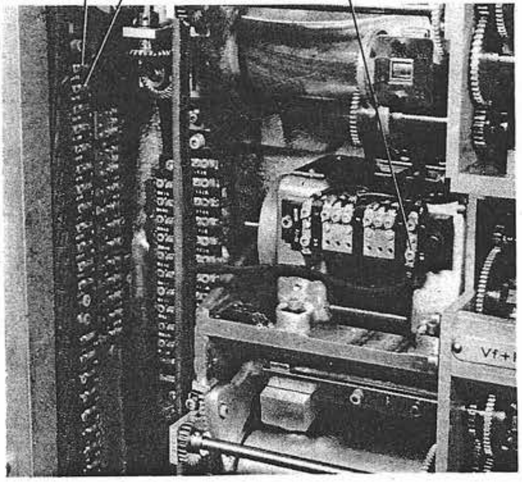
TARGET COURSE CONTROL



Ct INDICATOR

The *Ct* transmitter under cover 1 and the *Ct* indicator on the end of the star shell computer are energized whenever the computer power switch is ON. If the *Ct* indicator does not follow when the target angle handcrank is turned, refer to *Transmission Test Analysis*, page 180.

If the *Ct* indicator dial moves in jumps as the target angle handcrank is turned smoothly, the dial may be rubbing on the dial mask. Remove the window on the indicator and check the dial clearance.



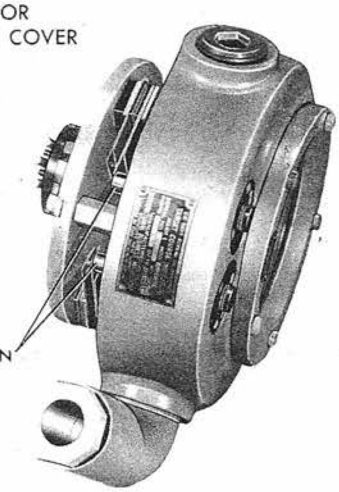
Vf+Pe BALLISTIC COMPUTER

When the *Sh* and *A* handcranks are at AUTO, the *Ct* motor may be controlled by the indicator push-buttons. If *Ct* does not drive when either push-button is depressed, remove cover 5 and check the operation of the relays.

If a relay does not operate when its controlling push-button is depressed, the trouble may be in either the relay itself, or the push-button circuit. Remove cover 4 and connect one end of a test jumper to terminal C1 of the *Vf* + *Pe* ballistic computer. Connect the other end of the jumper to terminal AR11 to energize the DECREASE relay, or to terminal AR12 to energize the INCREASE relay. If the relay then operates properly, the trouble is in the push-button circuit.

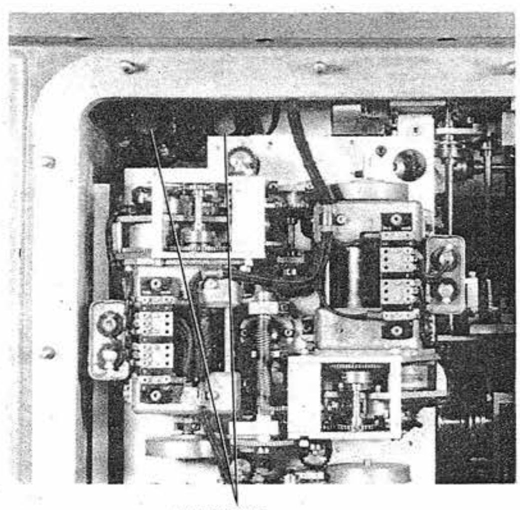
Gene Slover's US Navy Pages | Table of Contents

Remove the *Ct* indicator from the end of the star shell computer. Take out the eight screws holding the rear cover of the indicator, and remove the cover. Check the push-button switches, and the wiring from the indicator to the Computer Mk 1.



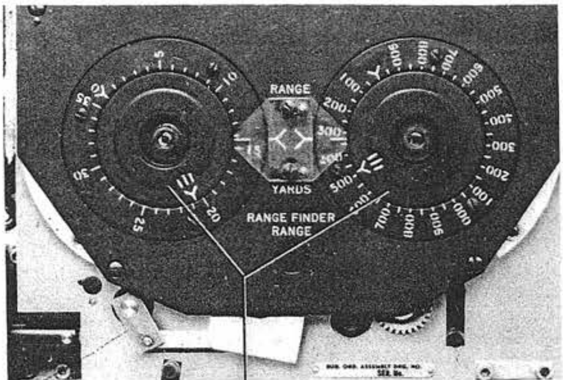
If a relay does not operate when the test jumper is connected, remove it and check the coil. For removal, see page 689.

If the *Ct* motor does not drive when either relay operates, but it does drive during rate control, the normally open relay contacts are probably faulty. Remove the unit and inspect these contacts.



The normally closed contacts on both relays are used to supply the *Ct* follow-up center contact. If they are faulty, the *Ct* follow-up will be inoperative during rate control.

THE RANGE RECEIVER

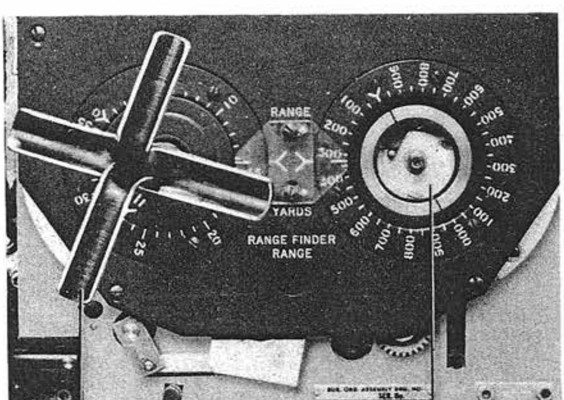


RANGE RECEIVER

The range receiver in Computer Mk 1 is a special type of double-speed receiver. Its function and normal operation are fully discussed in OP 1064.

The following symptoms of trouble may occur in the range receiver:

No operation
Sluggish or erratic operation
Operation in one direction only
Oscillation



DIAL WRENCH

FINE SYNCHRO DIAL REMOVED

No operation

If the range receiver fails to operate at all, either the servo motor is overloaded or else the follow-up control circuit is open.

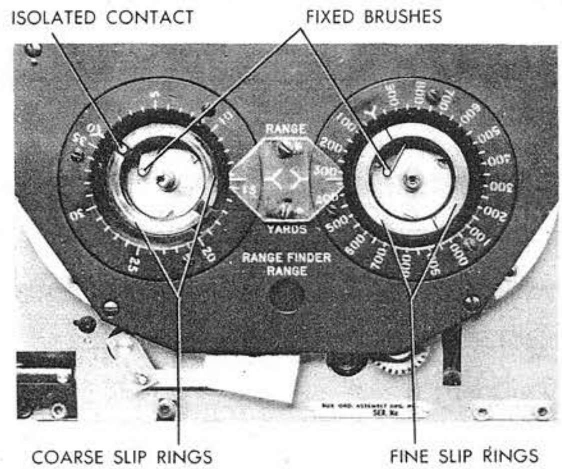
The servo motor may be overloaded by too much friction on the *jdR* line, or by tightness and sticks in the gearing. With the power OFF, use the generated range crank in the IN position to turn *jdR*. The *jdR* line, the *jRc* integrator, the *cR* line, and the *cR* dials should turn smoothly and easily.

If the line feels tight or sticky, remove cover 1 and check frictions A-164 and A-240. If these frictions cannot be adjusted to act smoothly, refer to *Shaft Line Devices*, OP 1140A. Check the associated gearing for tightness and sticks. See *Shaft Lines*, OP 1140A.

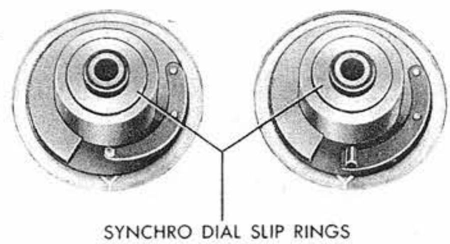
If the gearing is free, and the frictions properly adjusted, but the range receiver still does not operate, remove the coarse and fine synchro dials from their synchro shafts. Use a dial wrench for this purpose.

Gene Slover's US Navy Pages Table of Contents

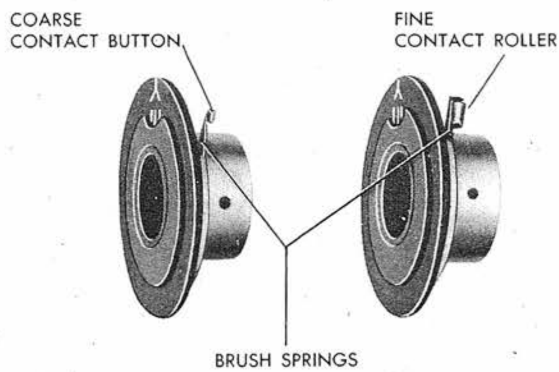
Inspect the contact surfaces and make sure that they are smooth and free from any oil, dirt, or other foreign matter. These contact surfaces include both slip rings and the isolated contact on the coarse dial assembly; both slip rings on the fine dial assembly; the slip ring on the bottom of each synchro dial, together with its corresponding fixed brush; and the coarse contact button and fine contact roller on their respective synchro dials.



Check that the brush springs on both the coarse and fine synchro dials are bent sufficiently to make *light contact* with the slip rings. Check that the fixed brush below each synchro dial is bent upwards sufficiently to make *light contact* with the synchro dial slip ring.

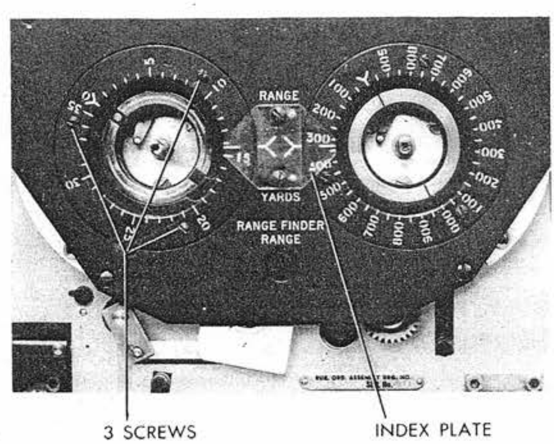


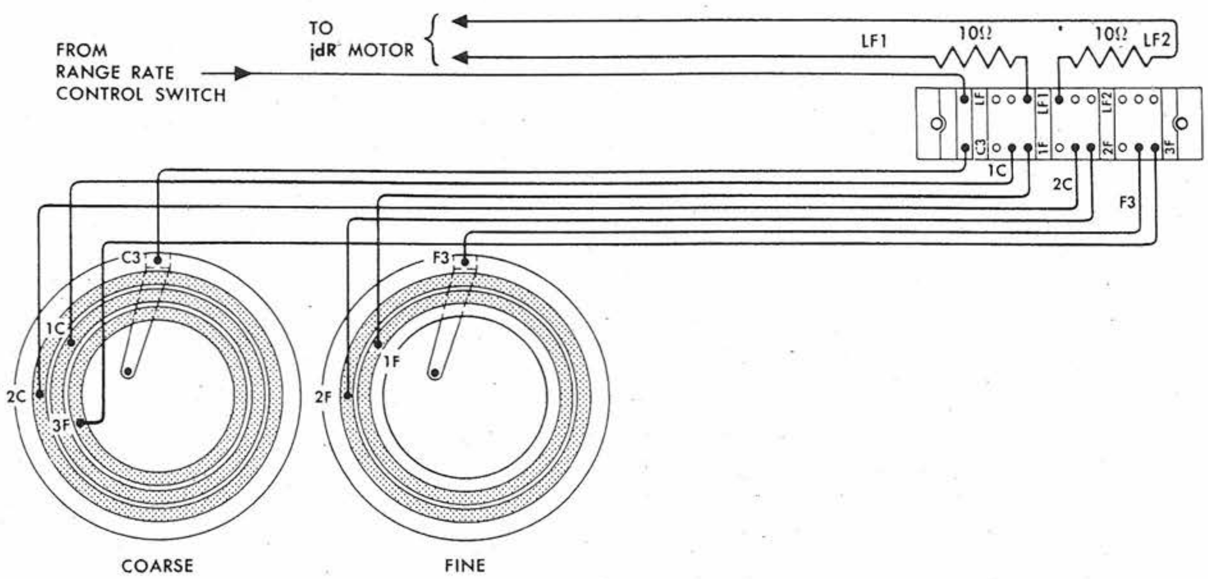
The proper bend for all four brush springs may be checked by measurement. Each brush spring should be deflected by its slip ring approximately 1/32 inch when the synchro dials are seated on the synchro shafts.



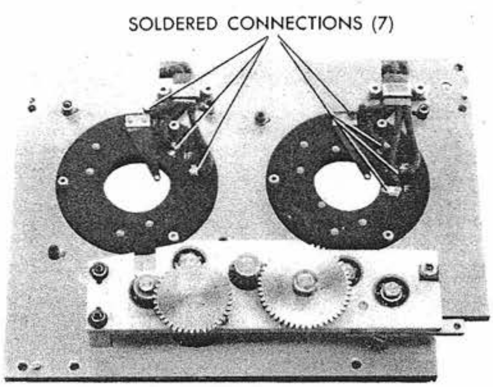
If the above parts have been checked and adjusted, but the range receiver still does not operate, it will be necessary to further disassemble the unit.

Remove the two screws holding the index plate, and lift the plate off. Remove the three screws holding the coarse ring dial in place, and remove the dial. Before removing the slotted ring and triangular clamp ring below the dial, mark both pieces in two places, on their adjacent inner diameters. Then remove the three flat-head screws and both rings. Next, remove the three screws holding the slip-ring plate. Do not mix these screws with the dial screws. Lift the plate out. Check the lower slip rings and their corresponding brushes for proper condition and proper contact. Follow the same instructions given for checking the upper slip rings and brushes.





FIXED SLIP RING CIRCUIT



Follow the same procedure in disassembling and checking the fine dial assembly. Make sure that the parts of the fine and coarse dial assemblies are kept separate while they are out of the instrument in order to avoid interchange.

Use a circuit tester to check for continuity from the fixed slip rings and brushes to the receiver terminal block at the right of the range dials. If any of these circuits are found to be open, remove the remainder of the receiver from the instrument. See *Removal of Mechanisms*, page 621. Check the soldered connections on the bottom of the lower slip rings, and the wiring to the terminal block. Check each of the 10-ohm resistors on the terminal block.

Check the range servo motor and capacitor. See *Servo Motors*, OP 1140A.

Sluggish or erratic operation

If the range receiver runs too slowly, check frictions A-164 and A-240. Check the associated gearing and shaft lines. Follow the disassembly procedure given above and check all contact surfaces.

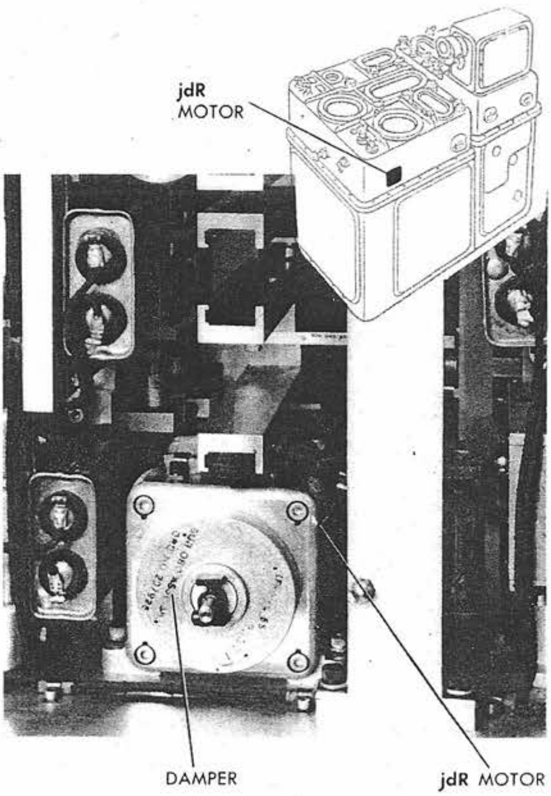
Gene Slover's US Navy Pages
Table of Contents

If the receiver will not synchronize to exact correspondence, or if it follows a smooth signal erratically, the fine control circuit is probably inoperative. Disassemble and check the entire slip-ring and brush assembly. Note that the fine control circuit is completed by the coarse synchro dial brush when the brush touches the isolated coarse contact. Therefore, both follow-up assemblies are involved in fine control.

Operation in one direction only

If the receiver will synchronize from a large displacement in one direction only, check the entire coarse control circuit for the direction of no operation.

If the receiver, when synchronized, will not follow a change of signal in one direction, and tends to overrun a signal change in the opposite direction, one of the fine slip ring circuits is open. Check the entire circuit from the inoperative slip ring to the receiver terminal block.



Oscillation

The commonest type of oscillation trouble occurs when the receiver is nearly synchronized, all circuits are properly energized, and the *Rrr* knob is set at 5. In this case, any oscillation existing will be rapid and of small amplitude, and can very often be stopped by turning the *Rrr* knob to a lower ratio. If any oscillation exists, however, it should be eliminated.

The oscillation may be caused by an inoperative magnetic damper on the *jdR* motor, by insufficient friction on the *jdR* line, or by improper action of the fine follow-up roller contact.

Check that the damper on the *jdR* motor is securely clamped to the motor shaft. Check the damper itself. See OP 1140A, page 440.

Check A-164. This friction may be increased in order to stop oscillation, provided that the synchronizing time of the receiver is not thereby made excessive.

Check the fine follow-up roller contact. It should be positioned by its supporting spring so that the roller lies flat on the slip rings when the inner dial is in place. When it is at the synchronized position, the roller should make good contact with both slip rings at the same time.

Reassembling the range receiver

Replace the receiver-unit plate assembly. See *Removal of Mechanisms*, page 623.

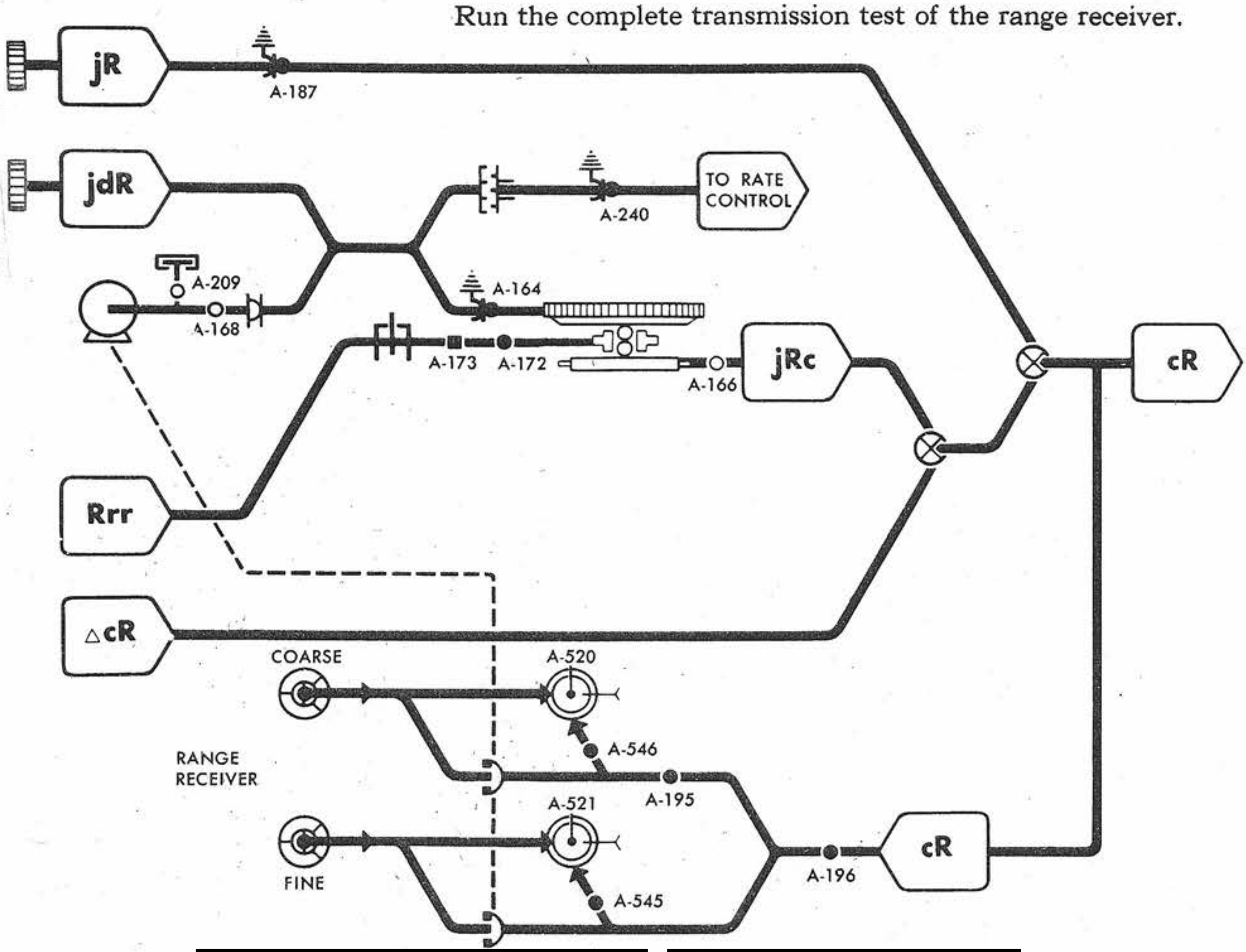
Replace the slip ring plate, then the clamp ring and the slotted ring, on both the coarse and fine dial assemblies. Make sure that the rings are replaced with the marks matched, and that no interchange of these parts has been made between fine and coarse.

Replace both ring dials, the index plate, and the coarse synchro dial.

Readjust A-546, A-545, A-195, A-196, A-520, and A-521, in the order given. See *Factory Adjustment Procedure*, page 827.

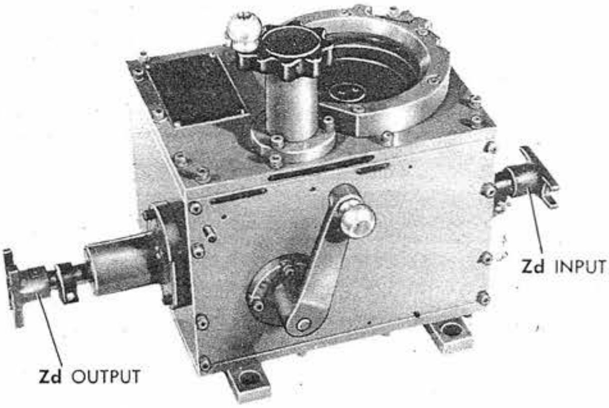
Check A-233, A-151, A-104, and A-138. See *Readjustment Procedure*.

Run the complete transmission test of the range receiver.



SELECTOR DRIVE

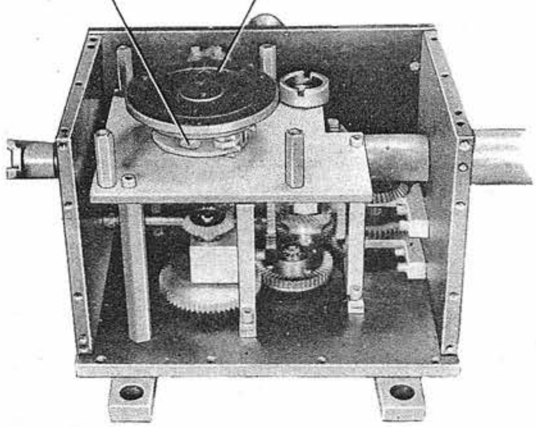
The operation and functional description of the Selector Drive Mk 1 are fully discussed in OP 1064. This section covers typical troubles in the unit, together with the readjustment procedure to be used in case of disassembly.

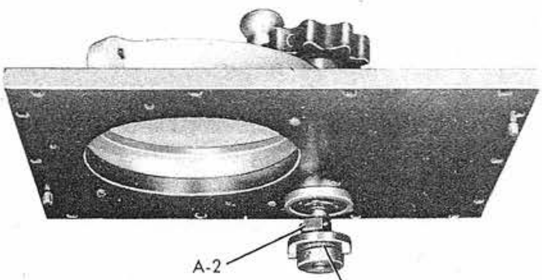


SELECTOR DRIVE MK 1

When the selector lever is at the DISCONNECT position, values of *Zd* from the stable element should merely rotate the dials in the selector drive. The *Zd* line in the computer may be set at any selected value by means of the selector drive handcrank. If the selected value drifts off when the stable element is driving, one or more of the following troubles may exist:

> The dials or dial gearing may be binding, causing the *Zd* input to back out the computer *Zd* line. Remove the top cover of the selector drive and check the dial clearance and planetary gearing. Refer to *Dial Assemblies and Counters,* OP 1140A.
>
> The handcrank holding friction or the handcrank drive friction may be too loose to hold the setting. Remove the handcrank from the top cover and check both friction adjustments. Refer to the readjustment procedure at the end of this section.

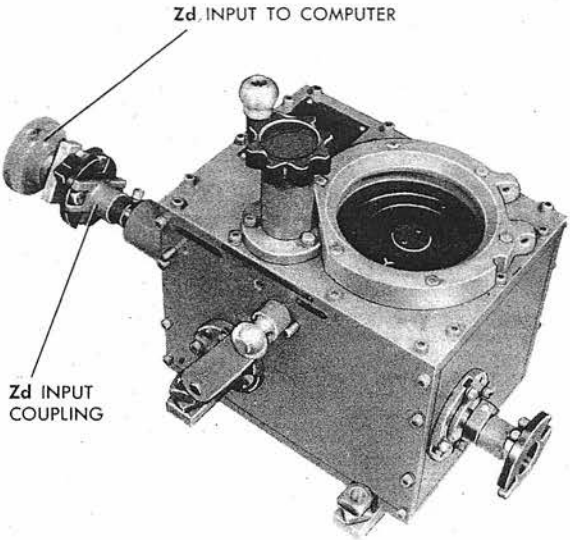




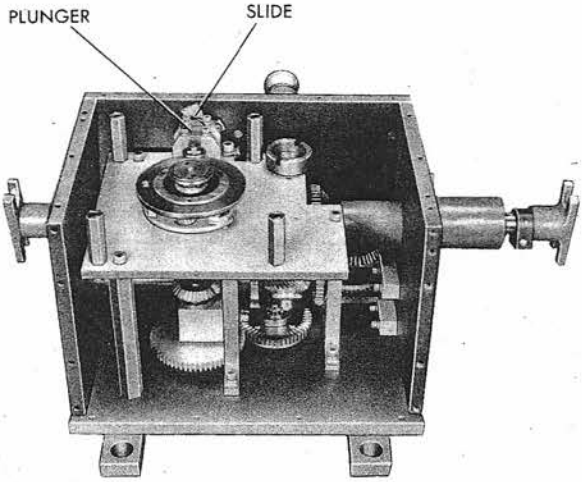
If handcrank inputs are ineffective when the selector lever is at the DISCONNECT or the CONNECT position, the cause may be that:

> The handcrank drive friction is too loose. Refer to the readjustment procedure for A-2.

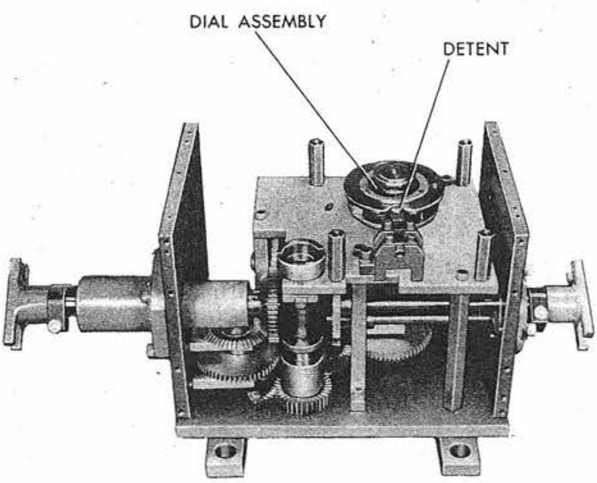
 Table of Contents



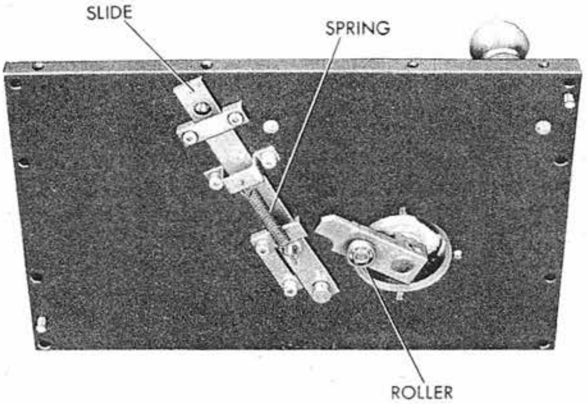
The gearing is binding. Disconnect the coupling on the *Zd* input to the computer and check whether the binding is in the computer or in the selector drive. Refer to *Shaft Lines,* OP 1140A.



Binding in the selector drive in the DISCONNECT or the CONNECT position may be caused by the coarse interlock mechanism. See OP 1064, page 375, for a detailed description of the coarse interlock. If the coarse interlock slide binds, the spring may not lift it up to the position where the hole is in position to receive the plunger. If the plunger binds, it may lock the dial assembly at the synchronized position. In either case, the plunger would be unable to back out of the detent and the dials could not turn. In such case, when the handcrank is turned, the drive friction should slip. However, if the friction is too tight, clamp A-1 may become upset.

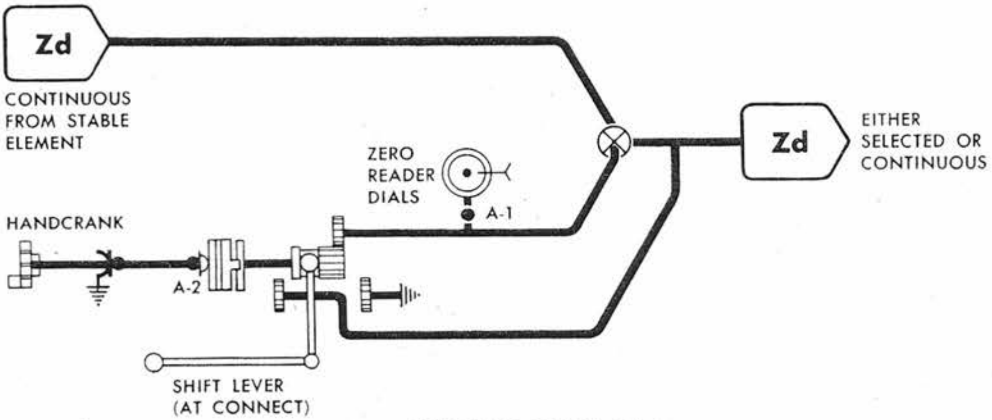


Remove the top cover and the dial mask, and shift the selector lever between LOCK and DISCONNECT to check operation of the interlock slide and plunger. If the slide binds, remove the side cover on which it is mounted to locate the cause of binding. Both the slide and the plunger should be free enough to be moved easily by their respective springs. When replacing this side cover, make sure that the selector-lever roller position matches the position of the recess in the sliding gear.



Readjusting the selector drive

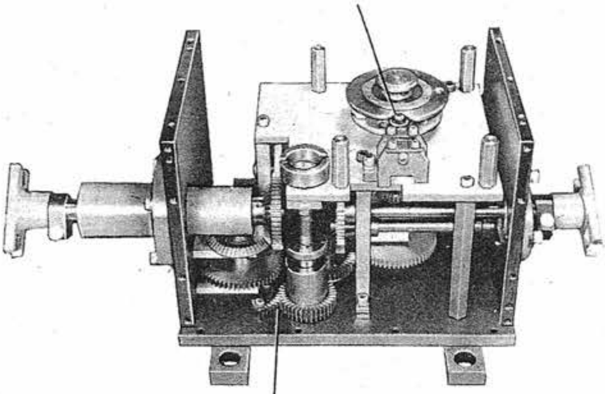
If the selector drive has been disassembled or is out of adjustment for any other reason, it should be completely checked and re-adjusted. In order to cover all adjustments, the following procedure should be used:



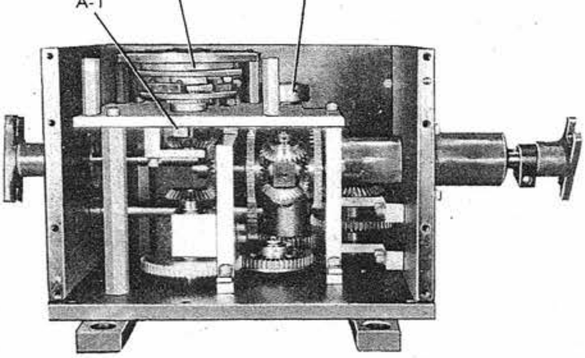
SELECTOR DRIVE MK 1

Remove the top cover plate and the dial mask.

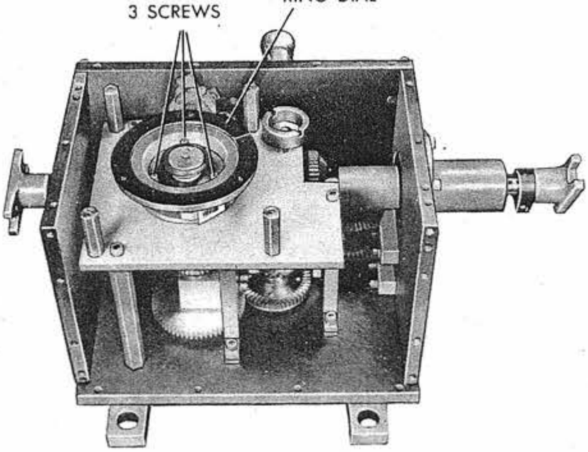
Table of Contents



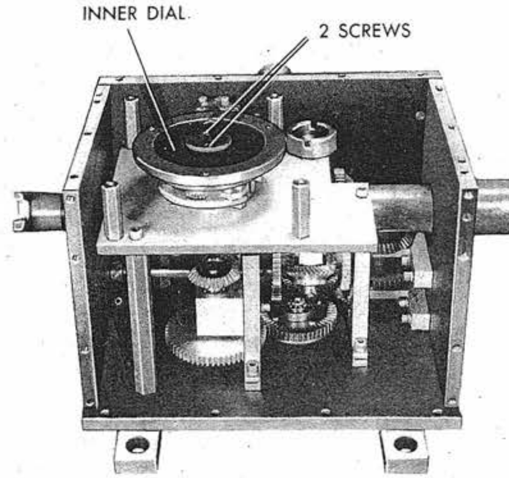
A-1. When the coarse interlock roller is in the detent, the fine interlock should be in correct position to permit the selector lever to be shifted to the LOCK position. See OP 1064, page 375, for a detailed description of the fine interlock.



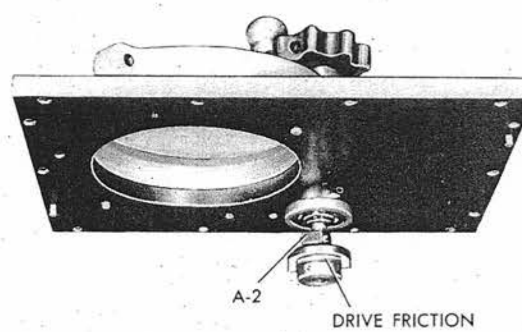
If the lever does not shift to LOCK, remove the side plate opposite the lever and loosen A-1. Hold the dial assembly to keep the coarse interlock in position and turn the handcrank input line until the fine interlock lines up. Shift the lever to the LOCK position. Tighten A-1. Replace the dial mask.



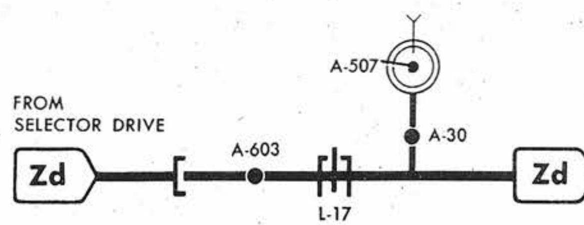
THE RING DIAL. With the interlock set and the lever in the LOCK position, the ring dial index should match the fixed index. If it does not match, remove the inner dial and loosen the three screws underneath. Slip the ring dial to match the fixed index and tighten the three screws. Replace the inner dial.



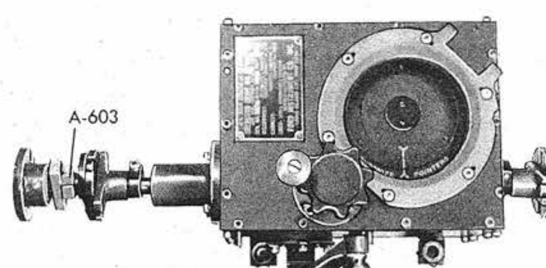
THE INNER DIAL. With the interlock set and the lever in the LOCK position, the inner dial index should match the ring dial index at the fixed index. If the inner dial does not match, loosen the two center screws. Slip the dial to the matched position and tighten the two screws.



DRIVE FRICTION, A-2. Set the top plate in place temporarily and engage the handcrank coupling. The handcrank drive friction should be tight enough to drive the line when the handcrank is turned, with the selector lever in either the CONNECT or the DISCONNECT position. It should be loose enough, however, to slip when L-17 in the computer is reached, or when the selector lever is in the LOCK position. If necessary, loosen A-2 and turn the threaded clamp to increase or decrease the friction as required. Tighten A-2. Replace and secure the side plate and the top plate.



HOLDING FRICTION. The handcrank holding friction should be sufficient to prevent the *Zd* input from backing out through the handcrank when the shift lever is in the CONNECT position except when the limit of L-17 in the computer is reached. If necessary, remove the handcrank and adjust the holding friction. Refer to OP 1140, page 166.



Check A-603. Refer to *Readjustment Procedure,* page 499.

Part 6
LUBRICATION

The Computer Mk 1 is clean and is thoroughly lubricated when it leaves the factory. Thereafter, it should be cleaned and lubricated at regular intervals depending upon the amount of use. The information given here concerns routine lubrication, but does not pertain to lubrication which necessitates the removal or disassembly of mechanisms. However, routine lubrication does require the removal of covers for access to the mechanisms to be lubricated. Therefore, lubrication should not be attempted when there is danger of dirt or excessive moisture entering the computer.

General Instructions

Before the instrument is lubricated, it must be cleaned of all metal chips, dirt, dust, and lint. Cleaning should be done with a vacuum cleaner and with a lint-free cloth or brush dipped in an approved solvent. The use of compressed air within the instrument is prohibited since it is liable to blow any loose dirt into bearings and onto gears. Lubricants, containers, and applicators must be kept clean and free from dirt and chip contamination.

Before applying fresh grease, remove the old grease with a lint-free cloth or brush dipped in an approved solvent. Fresh grease should be applied immediately after cleaning, to avoid any possibility of corrosion. It should be applied uniformly and in small quantities. After lubrication, any excess grease should be removed. Too much grease increases friction. Therefore, the least amount needed to produce a uniform coating should be applied.

The use of oil, especially on ball bearings and rollers, is principally to prevent corrosion. Consequently, oil should be used sparingly; preferably being applied a drop at a time by means of soft copper wire.

CAUTION

Care must be exercised to avoid getting oil or grease on synchro slip rings, follow-up control contacts, and parts made of natural rubber.

Lubricants

Oil

Where oil is specified, use Instrument Oil, BuOrd Specification 14-O-20(Ord), Standard Stock No. 14-O-975-25.

Grease

Where grease is specified, use Instrument Grease, BuOrd Specification 14-G-8(Ord), Standard Stock No. 14-G-980-800. If this is not available, use Bearing Grease, BuOrd Specification 14-G-10(Ord), Stan

Lubrication of Basic Mechanisms

Instructions for the routine lubrication of basic mechanisms used in the Computer Mk 1 are given below. These instructions are followed by a Lubrication Schedule in which the frequency of lubrication is specified.

Flat Cams

Where possible, clean all parts with solvent. Apply a thin coating of grease to cam grooves. Apply a film of oil to guide rails of cam follower, and 3 to 5 drops of oil to groove of each guide roller and to each bearing.

Component Solvers

Where possible, clean slides, guides, and other parts with clean brush or lint-free cloth dipped in solvent.

Apply 3 to 5 drops of oil to each bearing, roller groove, and pivot point.

Apply a thin coating of grease to grooves of spiral cams, or to lead screws, and to slots of vector gears and output racks.

Ballistic Computers

Thoroughly clean cam surfaces, guide rods, lead screws, and other parts with solvent. Make sure that cam surfaces are absolutely free from metal chips or dirt.

Apply a thin coating of grease to guide rods, lead screws, limit stops, and gearing.

Apply 3 to 5 drops of oil to each bearing.

Multipliers

Where possible, clean all parts with solvent.

Apply a thin coating of grease to lead screws, racks, and slots.

Apply 3 to 5 drops of oil to guide rails, rollers, pivots, and bearings.

Integrators

Thoroughly clean rollers, balls, and discs, using lint-free cloth or clean brush dipped in solvent. Be sure to remove any fine chips that may have been rolled flat on discs, balls, or rollers by rubbing with clean cloth or brush.

Lightly coat rollers, balls, discs, and working surfaces of carriage guide rails with grease.

Apply 3 to 5 drops of oil to all bearings except those that support discs. The latter should be lubricated with grease whenever integrators are disassembled.

Limit Stops

Clean threaded shafts with solvent. Apply a thin coating of grease to threads and run traveling nuts full length of shafts several times to distribute the grease uniformly.

Differentials

In differentials having spider shafts less than ¼ inch in diameter (such as those in follow-ups), lubricate gears and bearings with oil. In differentials having spider shafts ¼ inch or more in diameter, apply a thin coating of grease to all gearing. Apply sufficient oil to each bearing to form a protective film.

Gene Slover's US Navy Pages | Table of Contents

Jewelled differentials in double-speed receivers require no care since they are totally enclosed.

Gears

On low speed spur and bevel gears (gears that rotate less than 300 rpm), apply sufficient oil to gear teeth to form a protective film.

On high speed spur and bevel gears (such as those driven by the time motor), apply a thin coating of grease to gear teeth and rotate shafts several times to insure uniform distribution. Wipe off any excess, where possible, from sides of gears.

Bearings

Apply 3 to 5 drops of oil to all bearings.

Couplings

Apply a thin coating of grease to all pressure contact surfaces.

Worms and Worm Wheels

Clean with solvent and apply a thin coating of grease to teeth of worms and worm wheels.

Lubrication Schedule

The lubrication schedule is separated into four parts, each part covering a major unit of the computer. These units are: the control unit, the computer unit, the indicator unit, and the corrector unit. A lubrication schedule for the Star Shell Computer Mk 1 is also included.

The frequency of lubrication is based both upon hours of operation and upon time periods. If the hours of operation exceed 150 in one month or 500 in three months, the frequency of lubrication is governed by the hours of operation. Otherwise, the instrument should be lubricated at regular time periods.

The term "high speed" in reference to shafts and gears refers to those whose maximum speed exceeds 300 rpm. All others are low speed. Small differentials have spider shafts less than ¼ inch in diameter, such as those in follow-ups. All others are denoted as large differentials.

Control Unit

The control unit is located under cover No. 1.

LUBRICATE EVERY 150 HOURS OR MONTHLY.

Component Solvers

Lubricate guide rails, rollers, and pivots with oil. Lubricate cam grooves, slides, slots, and screws with grease.

Disc Integrators

Lubricate all bearings with oil.

Component Integrators

Lubricate all bearings with oil.

High Speed Gearing

Time line; first two pairs of gears connecting each servo motor; output of range integrator.

Lubricate all bearings with oil. Lubricate all gears with grease.

Limit Stops

Lubricate all limit stops with grease.
LUBRICATE EVERY 500 HOURS OR 3 MONTHS.

Disc Integrators

Lubricate rollers, balls, discs, working surfaces of carriage guide rails, and gears with grease.

Component Integrators

Lubricate rollers, balls, and gears with grease.

Low Speed Gearing

All gearing except that classified previously as high speed gearing.

Lubricate all bearings, all low speed spur and bevel gears, and all small differentials with oil. Lubricate all large differentials with grease.

Worms and Worm Wheels

Lubricate all worms and worm wheels with grease.

Couplings

Lubricate all oldham couplings with grease.

Computer Unit

Access to the computer unit is obtained by removing covers Nos. 3, 4, and 5.
LUBRICATE EVERY 150 HOURS OR MONTHLY.

Ballistic Computers

Lubricate guide rods, lead screws, limit stops, and gears with grease.
Lubricate all bearings with oil.

Disc Integrators

Lubricate all bearings with oil.

Component Solvers

Lubricate guide rails, rollers, and pivots with oil.
Lubricate cam grooves, slides, slots, and screws with grease.

Multipliers

Lubricate guide rails, rollers, and pivots with oil.
Lubricate slides, slots, and screws with grease.

High Speed Gearing

Time line; integrator gearing connecting discs and rollers; first two pairs of gears connecting each servo motor.

Lubricate all bearings with oil. Lubricate all gears with grease.

Limit Stops

Lubricate all limit stops with grease.
LUBRICATE EVERY 500 HOURS OR 3 MONTHS.

Disc Integrators

Lubricate rollers, balls, discs, working surfaces of carriage guide rails, and gears with grease.

Table of Contents

Flat Cams

Lubricate cam grooves with grease. Lubricate guide rails of cam followers, guide rollers, and bearings with oil.

Complementary Error Corrector

Lubricate cam grooves, slides, and slots with grease. Lubricate rollers, pivots, and bearings with oil.

Low Speed Gearing

All gearing except that classified previously as high speed gearing. Lubricate all bearings, all low speed spur and bevel gears, and all small differentials with oil. Lubricate all large differentials with grease.

Worms and Worm Wheels

Lubricate all worms and worm wheels with grease.

Intermittent Drives

Lubricate cams, followers, sliding couplings, and gears with grease. Lubricate bearings with oil.

Couplings

Lubricate pressure contact surfaces of oldham couplings with grease.

Indicator Unit

The indicator unit is located under cover No. 2. The star shell computer must be removed before cover No. 2 can be removed. Monthly lubrication of the mechanism in the indicator unit is not specified because this gearing is subject to little wear and because the star shell computer must be removed to obtain access.

LUBRICATE EVERY 500 HOURS OR 3 MONTHS.

High Speed Gearing

B′gr line; *E′g* line; first two pairs of gears connecting each servo motor. Lubricate all bearings with oil. Lubricate all gears with grease.

Low Speed Gearing

Other gearing not specified above.

Lubricate all bearings, all low speed spur and bevel gears, and all small differentials with oil. Lubricate all large differentials with grease.

Intermittent Drives

Lubricate cams, followers, sliding couplings, and gears with grease. Lubricate bearings with oil.

Couplings

Lubricate pressure contact surfaces of oldham couplings with grease.

Corrector Unit

Access to the corrector unit is obtained by removing covers Nos. 6, 7, and 8.

LUBRICATE EVERY 150 HOURS OR MONTHLY.

Component Solvers

Lubr Gene Slover's US Navy Pages iv Table of Contents cam

grooves, slides, and slots with grease.

Multipliers

Lubricate guide rails, rollers, and pivots with oil. Lubricate slides, slots, cam grooves, and screws with grease.

Computers

Lubricate guide rails, rollers, and pivots with oil. Lubricate cam grooves, slides, and slots with grease.

High Speed Gearing

B′gr line; *L* line; *E′g* line; *Zd* line; first two pairs of gears connecting each servo motor.
Lubricate all bearings with oil. Lubricate all gears with grease.

Limit Stops

Lubricate all limit stops with grease.
LUBRICATE EVERY 500 HOURS OR 3 MONTHS.

Low Speed Gearing

All gearing except that classified previously as high speed gearing. Lubricate all bearings, all low speed spur and bevel gears, and all small differentials with oil.
Lubricate all large differentials with grease.

Worms and Worm Wheels

Lubricate all worms and worm wheels with grease.

Intermittent Drives

Lubricate cams, followers, sliding couplings, and gears with grease. Lubricate bearings with oil.

Couplings

Lubricate pressure contact surfaces of oldham couplings with grease.

Star Shell Computer

Access to the mechanisms of the star shell computer is obtained by removing the front and rear covers of the star shell computer case.
LUBRICATE EVERY 150 HOURS OR MONTHLY.

Multipliers

Lubricate guide rails, rollers, and pivots with oil.
Lubricate slides, slots, and screws with grease.

High Speed Gearing

Lubricate all bearings with oil.
Lubricate all gears with grease.

Limit Stops

Lubricate all limit stops with grease.
LUBRICATE EVERY 500 HOURS OR 3 MONTHS.

Low Speed Gearing

All gearing except that classified previously as high speed gearing. Lubricate all bearings and all low speed spur and bevel gears with oil.
[illegible] w [illegible]

Gene Slover's US Navy Pages
Table of Contents

Part seven

Enter these page numbers in your reader's page block to go directly to them.

REMOVAL OF MECHANISMS

Table of Contents

Gene Slover's US Navy Pages | Table of Contents

Enter these page numbers in your reader's page block to go directly to them.

Gene Slover's US Navy Pages

Table of Contents

Introduction

This section of the book is intended for use when it is necessary to remove any part of the mechanism for repair or replacement. It is presented mainly as a pictorial guide with a minimum of accompanying text. The procedures given here agree with sound and established practices for dealing with complicated mechanisms. Therefore, it is advisable for all maintenance personnel to adhere closely to the given instructions and to check each operation against the illustrations.

Before removing any mechanism, a careful check should be made to determine the cause of trouble. If it is of a simple nature, such as a poor gear mesh, the trouble can very often be corrected without taking the mechanism apart.

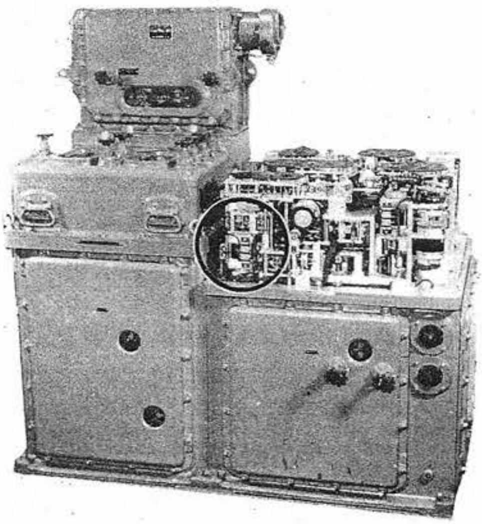
In the following chapters the location of each mechanism is shown and information on how to remove it follows in simple steps. In cases where it is necessary to remove other units to reach the desired mechanism, the interfering units are listed immediately after the mechanism title and in the order in which they should be removed. As the various screws are removed, their size and length should be noted, so they can be replaced in their proper positions. This is especially important where several different lengths of the same size screw are used near each other. Any unit which is located with dowel pins should first be worked back and forth carefully to free them. Where a taper pin is removed, it should always be replaced in its original hole. While removing mechanisms from the computer, care should be taken to avoid damaging gears, contact arms, springs, and other small parts. The removed mechanisms should be carefully placed aside until ready for reassembly. It is advisable to loosen all adjustments that are upset by the removal of mechanisms so that the possibility of damage to other parts is reduced.

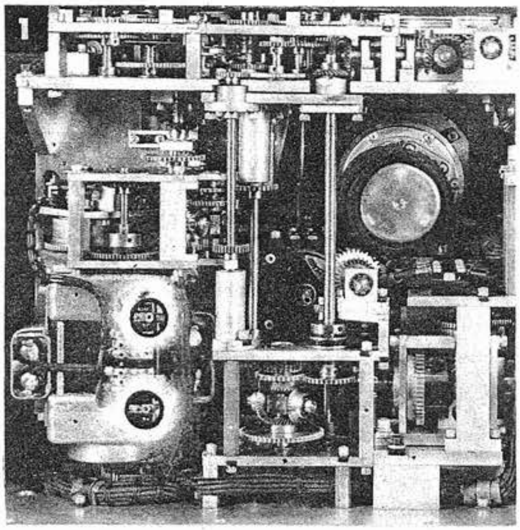
In order to repair a mechanism, reference should be made to the methods and checks given in OP 1140A. All mechanisms should be cleaned, inspected, and relubricated before they are reinstalled. The electromechanical assemblies (follow-ups, clutches, locks, receivers, etc.) should be bench checked before they are reinstalled.

Reassembly of the removed parts is the reverse of the removal procedure. For some mechanisms, special notes are given to assist in reassembly. The requirements given below apply to the reassembly of all mechanisms. Shafts should have proper end-play and freedom. Bearings must be absolutely clean so that the shafts can run smoothly. Gear meshes must be free, yet have a minimum amount of lost motion. Electrical wiring should be checked to see that all wires are connected to proper terminals. The cables should clear all sharp corners and gears.

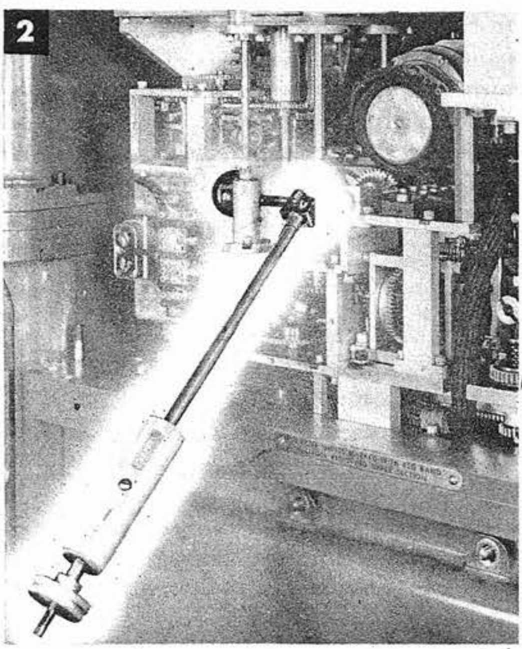
Removal and reinstallation of mechanisms will upset the relationship between the parts which were removed and those that remained in the computer. For each mechanism, the numbers of the points at which adjustments must be made to re-establish the correct relationships are listed in the sequence in which they should be made. Detailed information for making each adjustment can be found in *Readjustment Procedure,* page 232. The computer must be completely reassembled before readjustment is begun. If a large number of mechanisms were removed, so that extensive readjustment is necessary, it is advisable to follow the instructions given under *Factory Adjustment Procedure,* page 815.

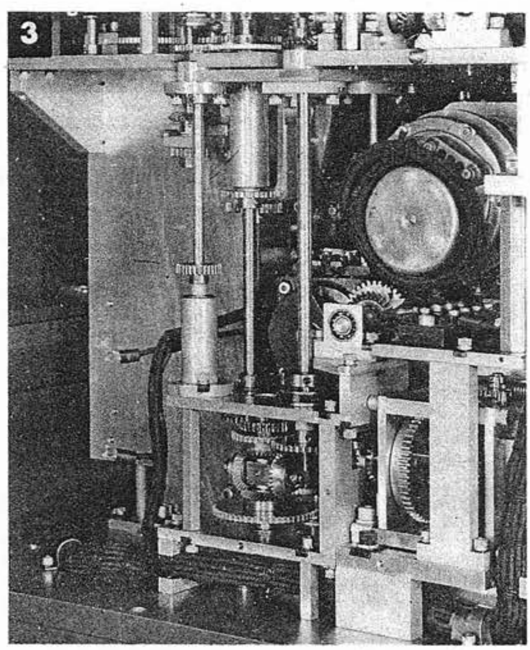
jE FOLLOW-UP





1 Remove the two screws connecting cable leads N and NN to the servo-motor terminal block.





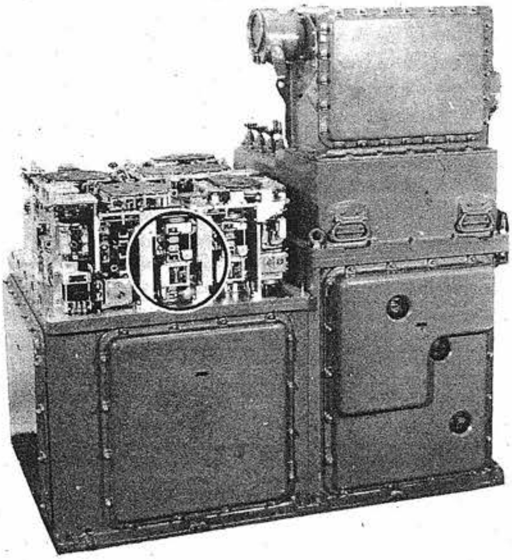
2 Using an angle screw driver, remove the screw securing the cable clamp above the capacitor. Free the cable.

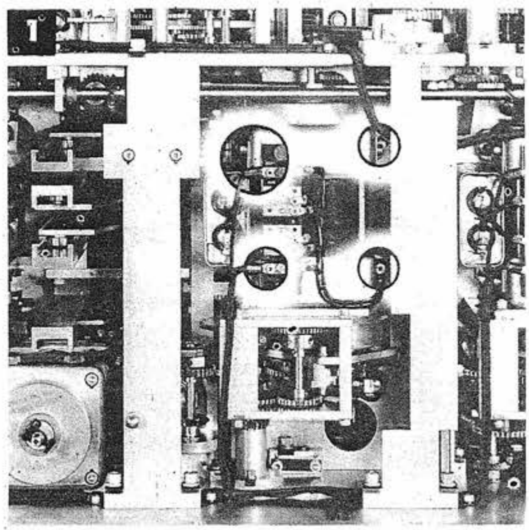
3 Remove the four screws securing the motor to the mounting plate. Remove the follow-up.

To reinstall the *jE* follow-up, reverse the removal procedure.

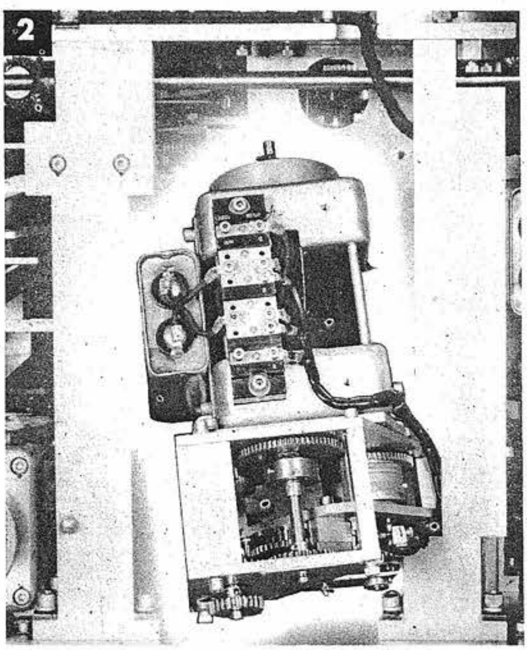
Readjust clamp A-529.

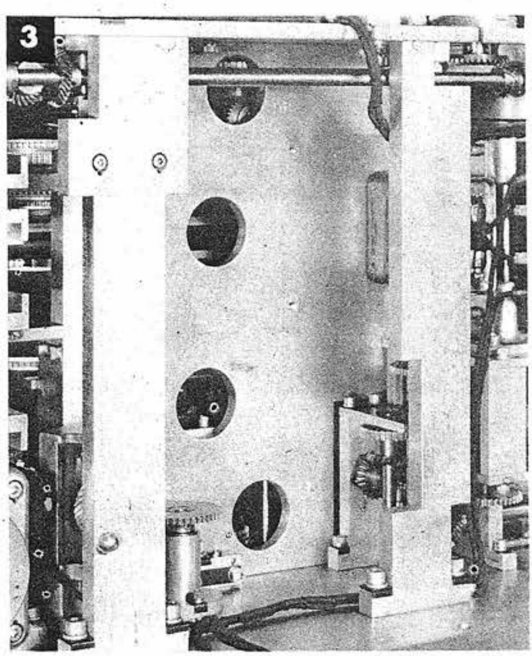
RdBs FOLLOW-UP





1 Remove the two screws connecting cable leads M and MM to the servo-motor terminal block. Remove the four screws securing the follow-up to the mounting plate.





2 Tilt the lower end of the follow-up outward to clear the shaft above it.

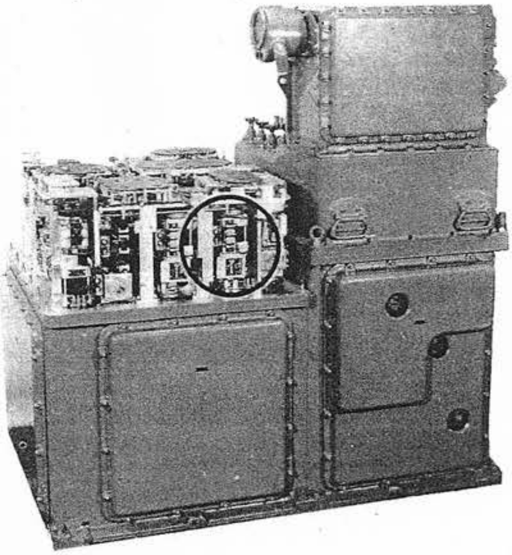
3 Remove the follow-up.

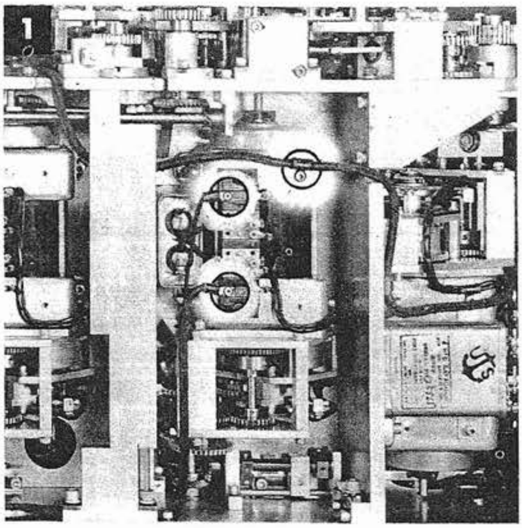
To reinstall the *RdBs* follow-up, reverse the removal procedure.

Readjust clamp A-121.

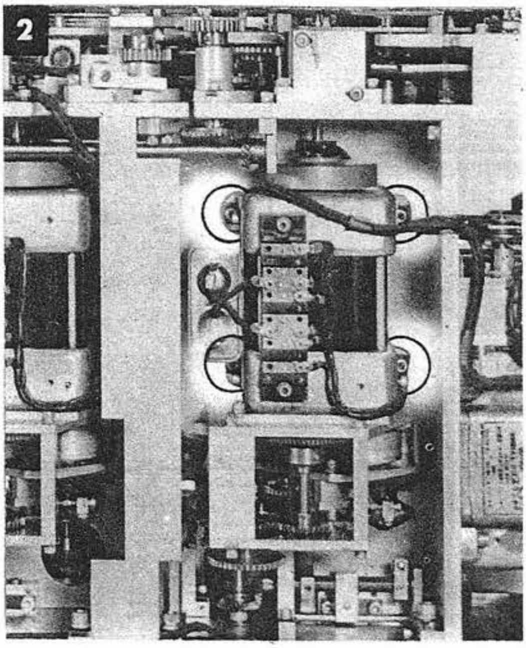
Run tests.

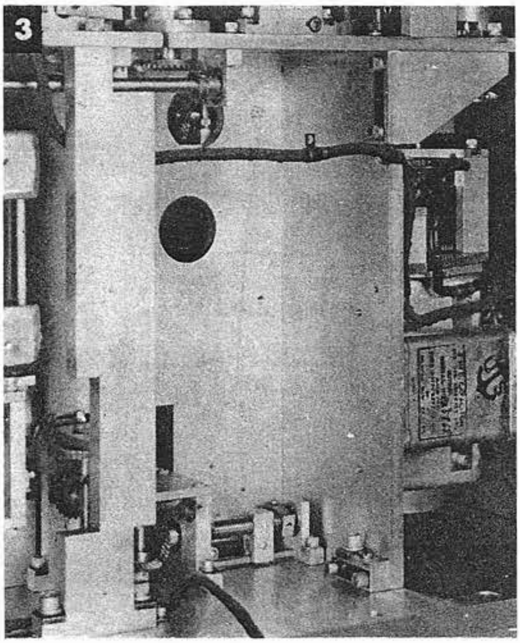
dRh FOLLOW-UP





1 Remove the two screws connecting cable leads P and PP to the servo-motor terminal block. Remove the screw securing the cable clamp to the upper end of the motor case. Free the cable.





2 Remove the four screws securing the motor to the mounting plate.

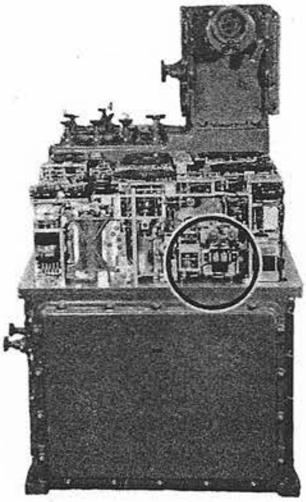
3 Remove the follow-up.

To reinstall the *dRh* follow-up, reverse the removal procedure.

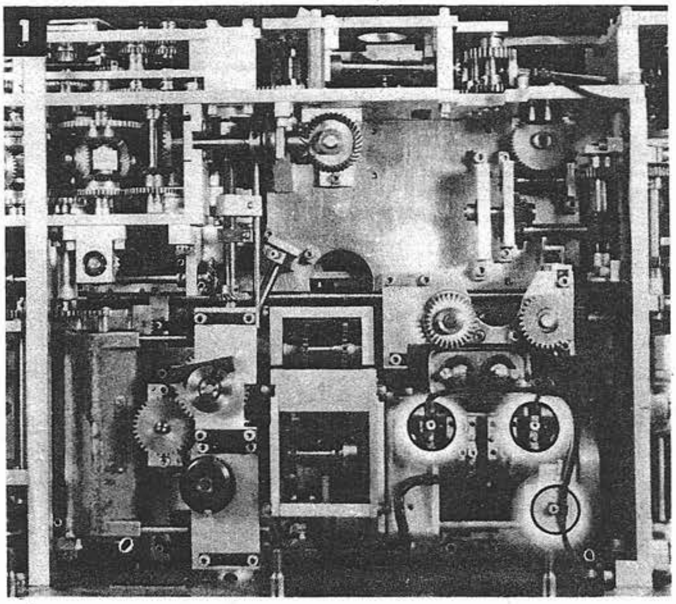
Readjust clamp A-119.

Run tests.

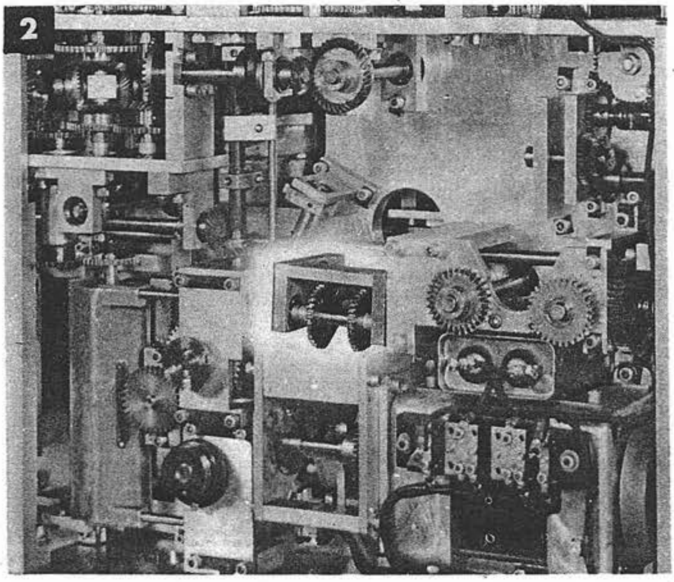
dR FOLLOW-UP

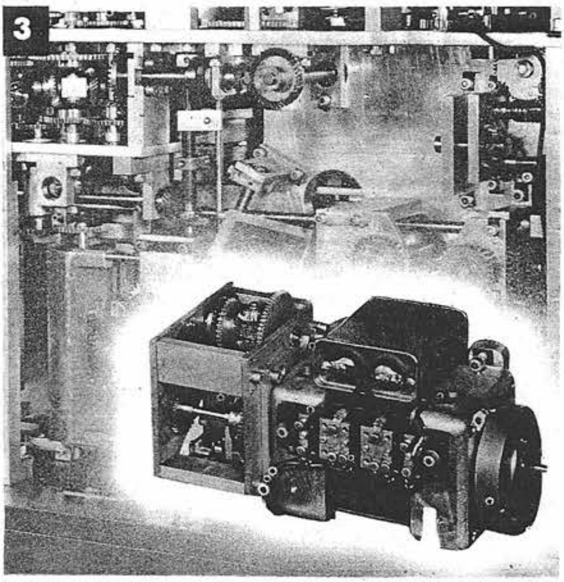


1 Remove the two screws connecting cable leads E and EE to the servo-motor terminal block. Remove the screw securing the cable clamp to the servo motor. Free the cable.

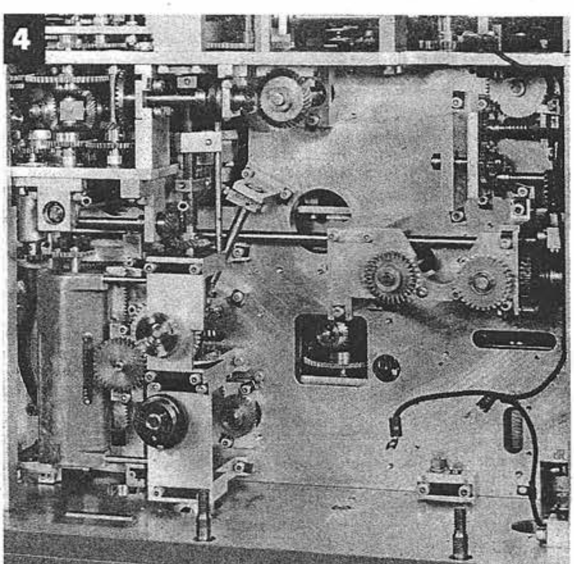


2 Remove the two screws securing the gearing directly above the follow-up to the mounting plate. Now the gearing can be shifted.





3 Remove the four screws securing the motor to the mounting plate. Lift the loosened gearing and tilt the follow-up downward to gain clearance.



4 Remove the follow-up and the gearing assembly.

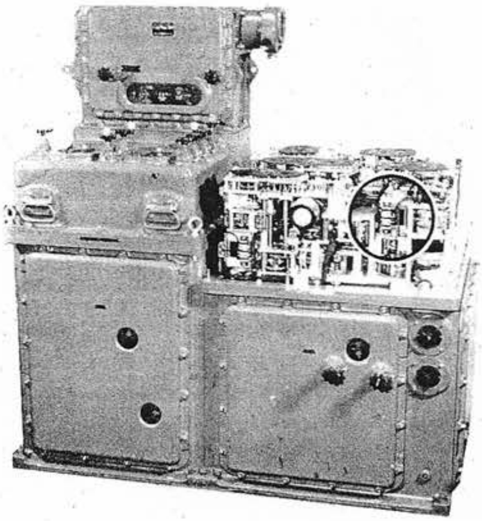
To reinstall the *dR* follow-up, reverse the removal procedure.

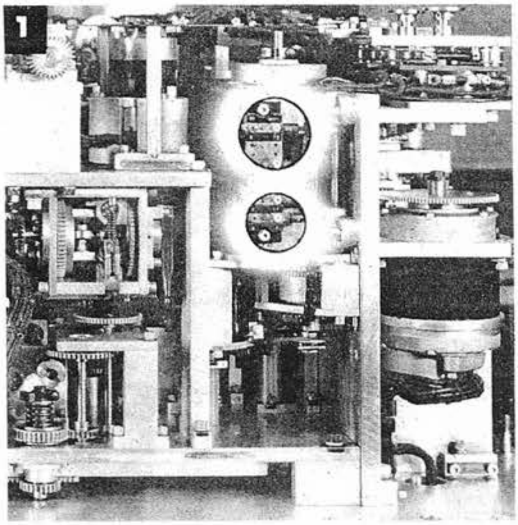
Place both the gearing assembly and the follow-up in their approximate positions before inserting holding screws.

Before tightening the screws, position the gearing assembly to obtain the proper gear meshes.

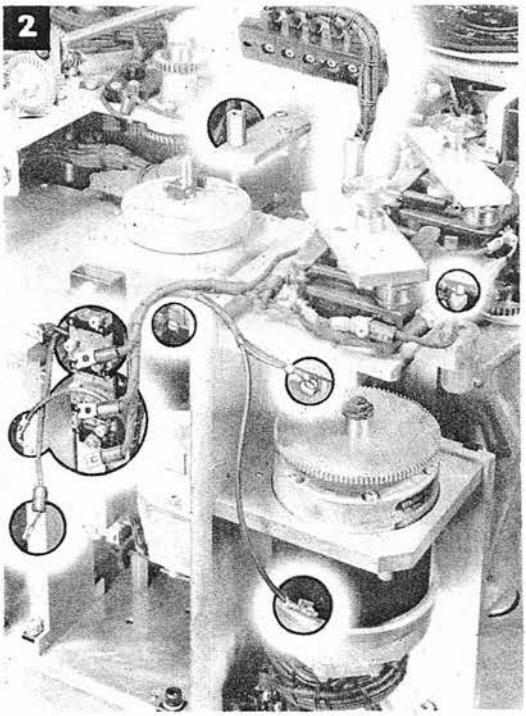
Readjust clamp A-163.

Sh FOLLOW-UP



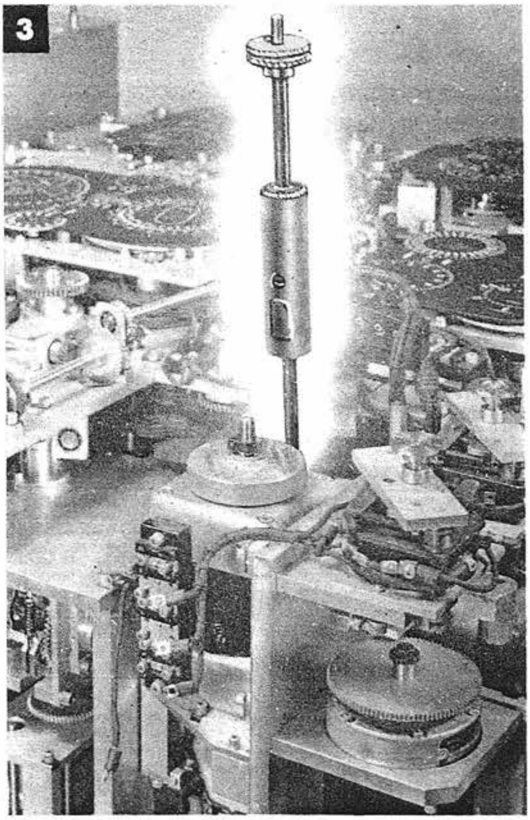


1 Remove the four screws connecting cable leads K, KK, K7 and K2 to the servo-motor terminal block. Loosen the two screws securing the terminal block to the servo motor. Free the K lead.



2 Remove the two screws connecting the capacitor leads to the terminal block.
Remove the screw connecting the lead from the contact assembly to the terminal block.
Remove the two screws connecting leads 1K and 2K to the range rate control switch assembly.
Remove the two screws securing the terminal block which is next to the *Sh* follow-up. Lay the block back, out of the way.
Remove the screw holding the cable clamp to the upper end of the servo motor case. Free the cable.

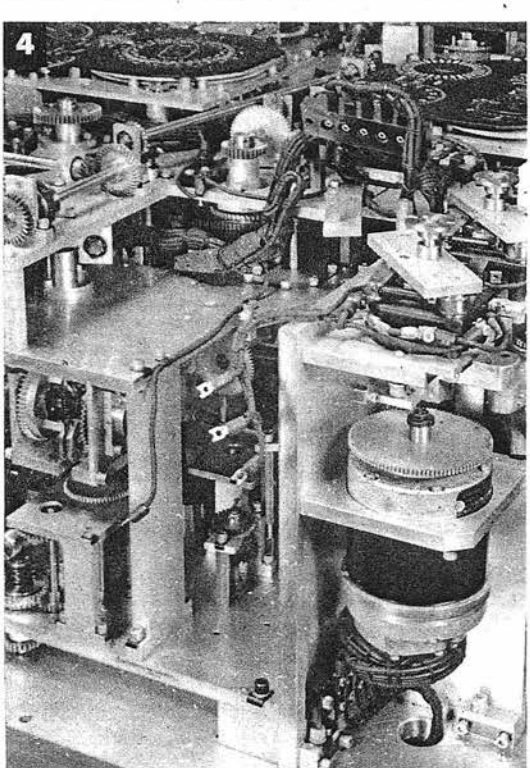
Table of Contents



3 Remove the screw securing the cable clamp and the upper capacitor bracket to the servo motor.

Using an angle screw driver, remove the lower screw securing the capacitor. Remove the capacitor.

Remove the four screws securing the servo motor to the mounting plate. Use an angle screw driver to remove the two back screws.



4 Remove the follow-up.

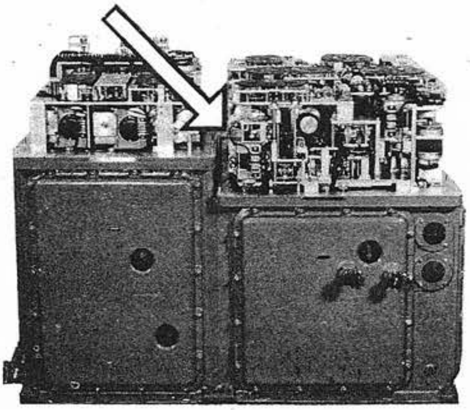
To reinstall the *Sh* follow-up, reverse the removal procedure.

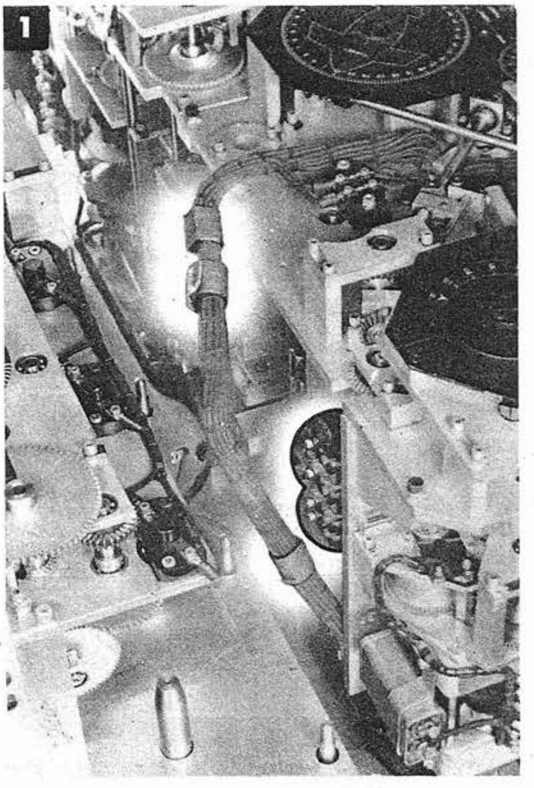
Readjust A-137.

Run rate control tests.

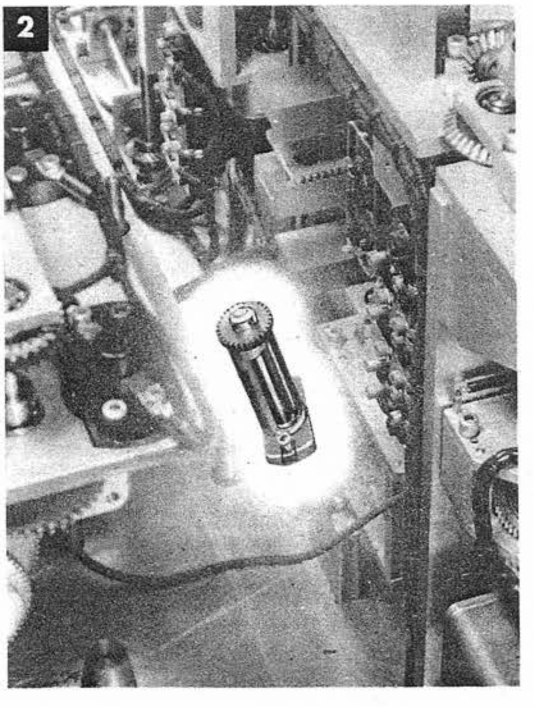
Ct (A) FOLLOW-UP

Star Shell Computer, page 804
Cover 2, page 238

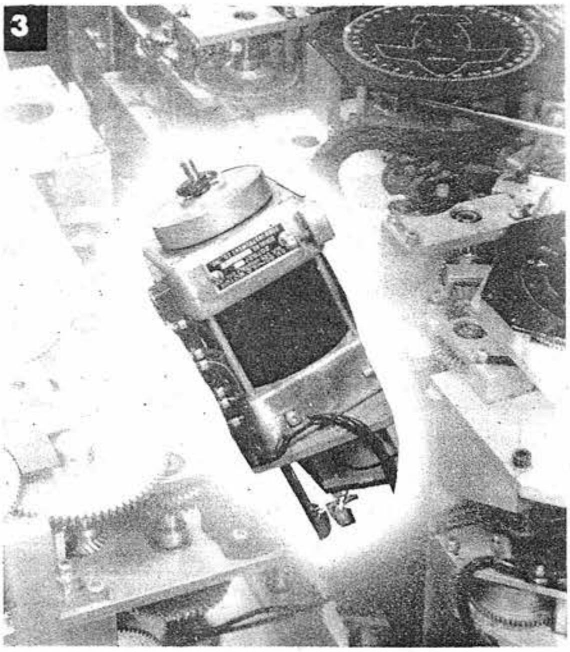




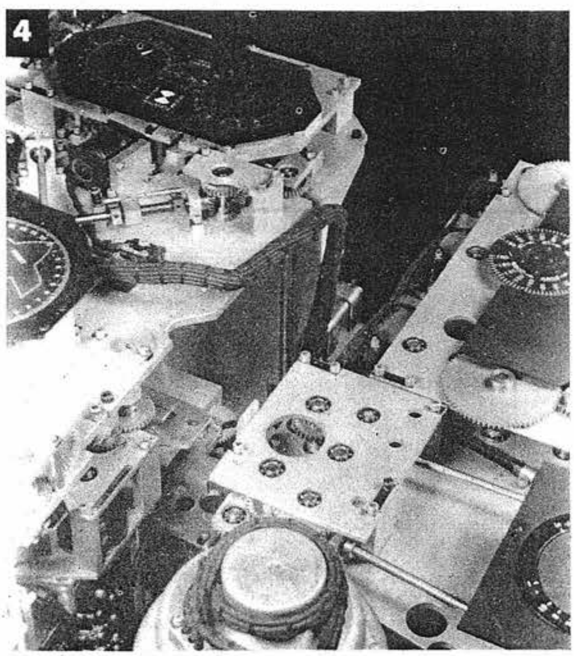
1 Remove the four screws connecting cable leads RR, TA2, TA1 and R1 to the servo terminal block.
Remove the three screws securing the clamps on the cable around the *Ct* follow-up. Free the cable.



2 Remove the two screws securing the shaft assembly adapter to the base plate located near the *Ct* follow-up.
Remove the adapter and shaft assembly.



3 Remove the four screws securing the servo motor to the mounting plate. Push the cable to one side. Turn the motor to free it from the meshing gears.



4 Remove the follow-up.

To reinstall the *Ct* follow-up, reverse the removal procedure.

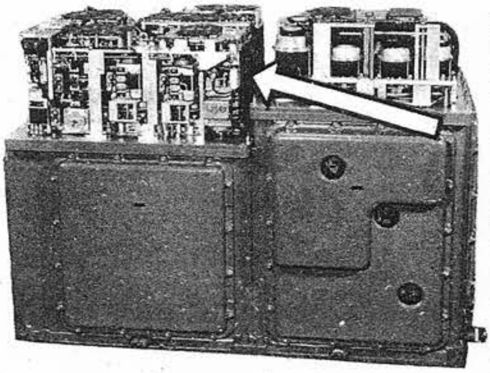
Readjust A-136, A-137, and A-258.

Run rate control tests, and the transmission test of the *Ct* indicator.

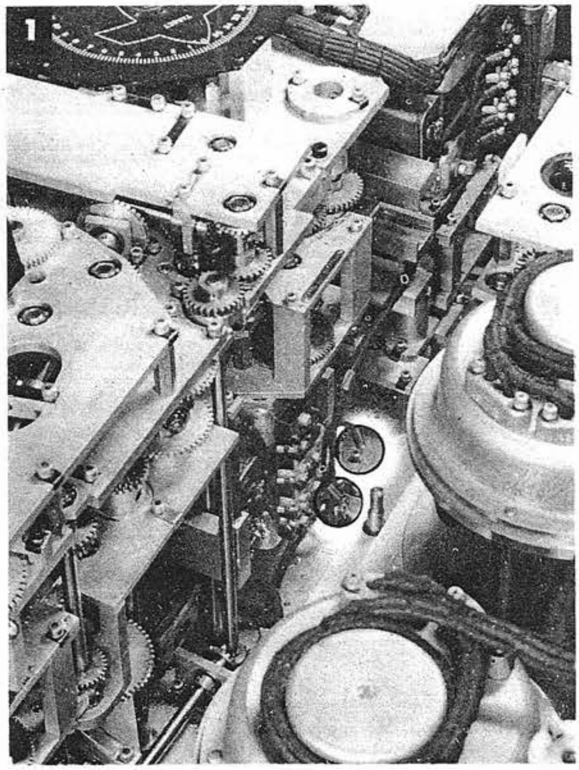
Replace the rear cover and the star shell computer.

Readjust the star shell computer to the instrument.

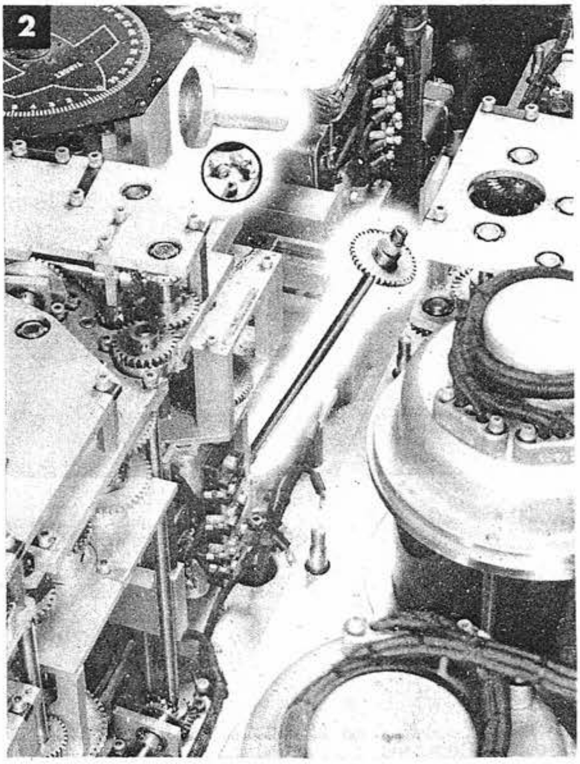
RdE FOLLOW-UP



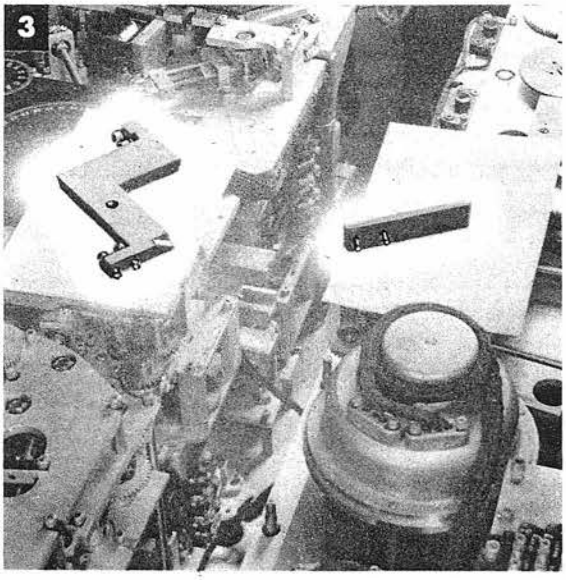
Star Shell Computer, page 804
Cover 2, page 238



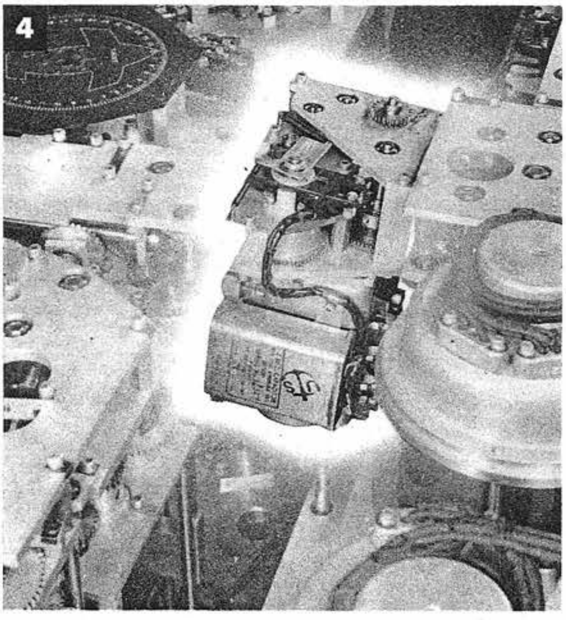
1 Remove the two screws connecting cable leads S and SS to the servo terminal block.



2 Remove the two screws securing the adapter and shaft assembly beside the *RdE* follow-up.
Remove the adapter and shaft assembly.

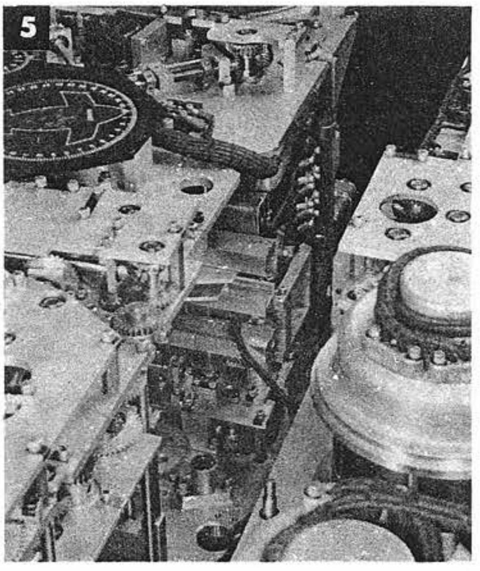


3 Remove the two screws securing the guide post to the top plate of the rear unit. Remove the guide post.
Remove the three screws securing the supporting bracket located near the lower end of the *RdE* follow-up. Remove the bracket.



4 Remove the four screws securing the motor to the mounting plate. Slide the follow-up out, and lift it straight up.

5 Remove the follow-up.



To reinstall the *RdE* follow-up, reverse the removal procedure.

Readjust clamp A-118.

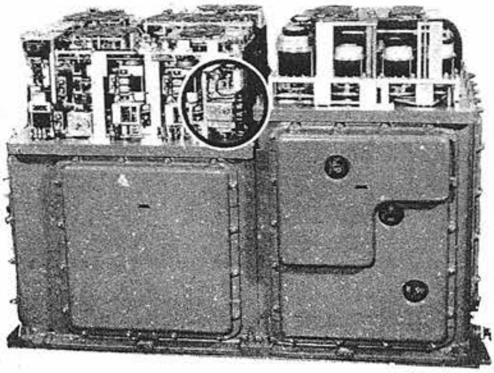
Run tests.

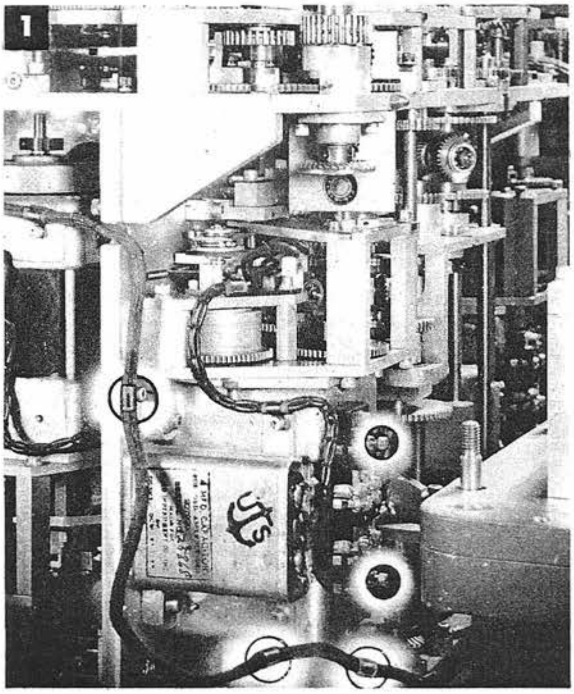
Replace the rear cover and the star shell computer.

Adjust the star shell computer to the instrument.

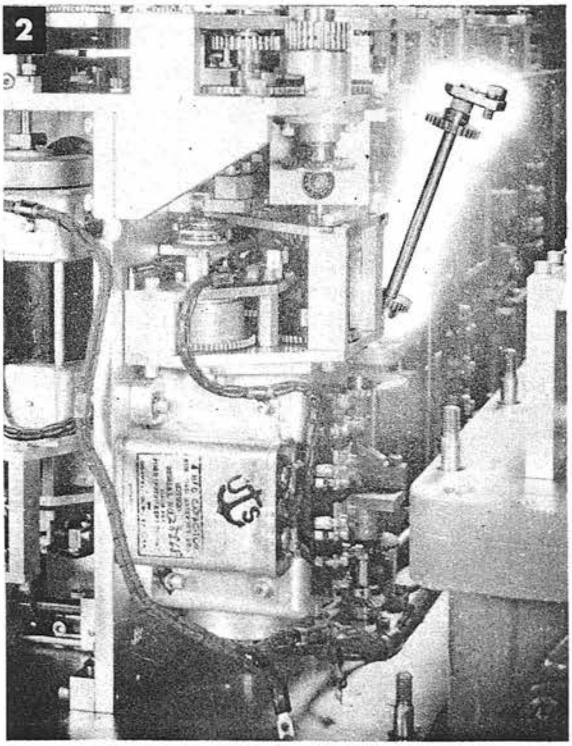
jBr FOLLOW-UP

Star Shell Computer, page 804
Cover 2, page 238



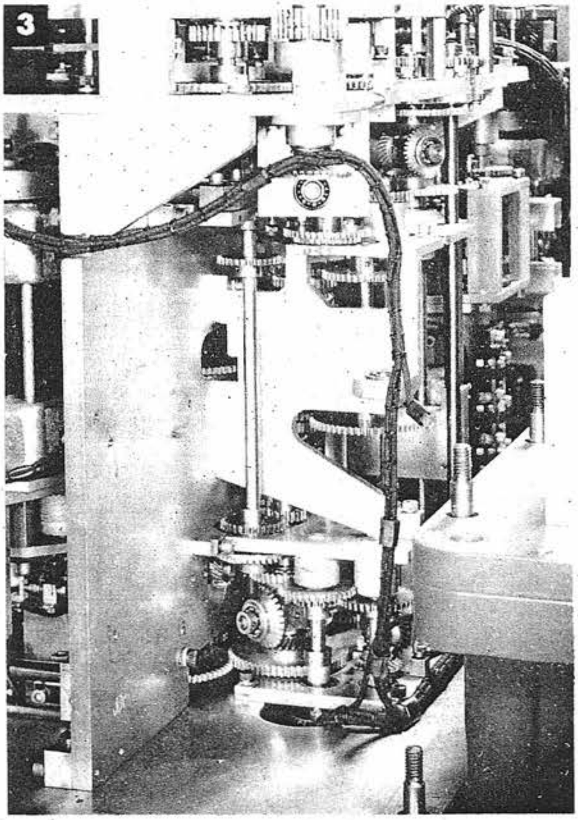


1 Remove the two screws connecting cable leads T and TT to the servo-motor terminal block.
Remove the three screws securing the cable clamps near the follow-up.
Free the cable.



2 Remove the two screws securing the hanger to the top plate beside the *jBr* follow-up.
Remove the shaft assembly and hanger.

Table of Contents



3 Using an angle screw driver, remove the four screws securing the motor to the mounting plate. Remove the follow-up.

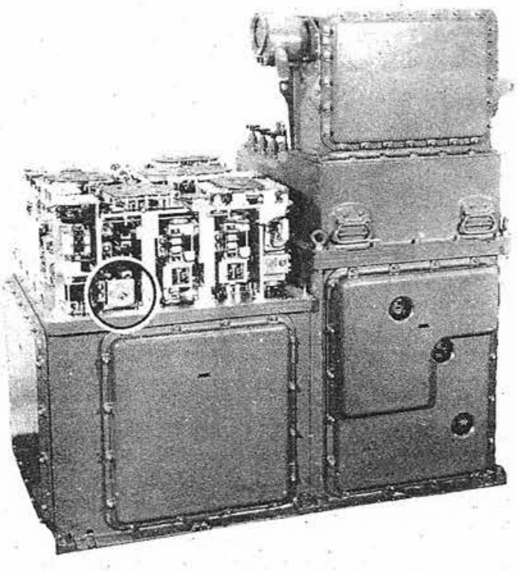
To reinstall the *jBr* follow-up, reverse the removal procedure.

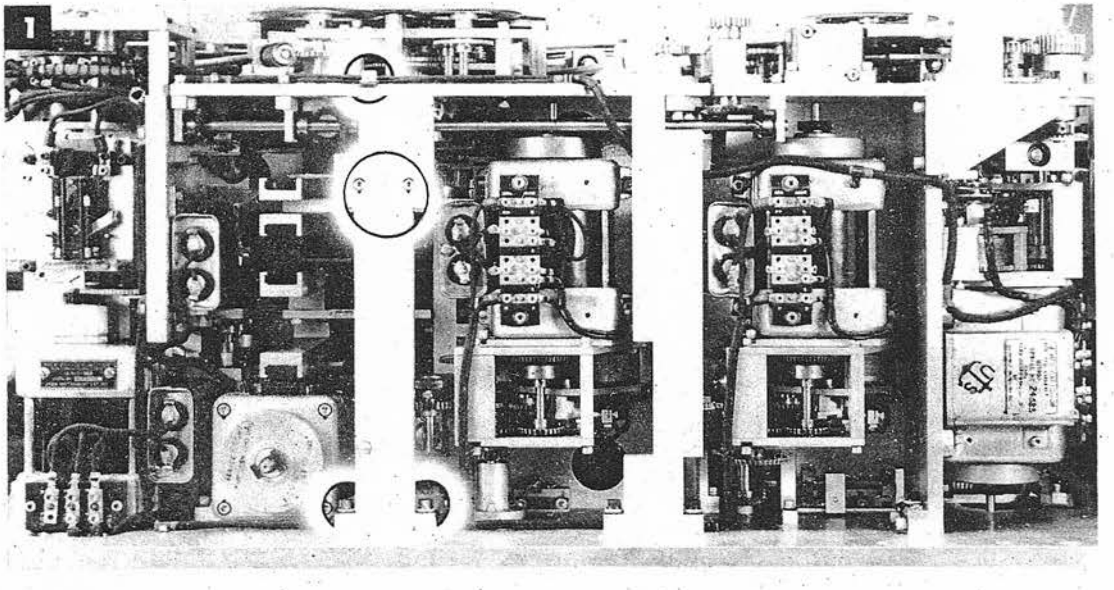
Readjust clamp A-533.

Replace the rear cover and the star shell computer.

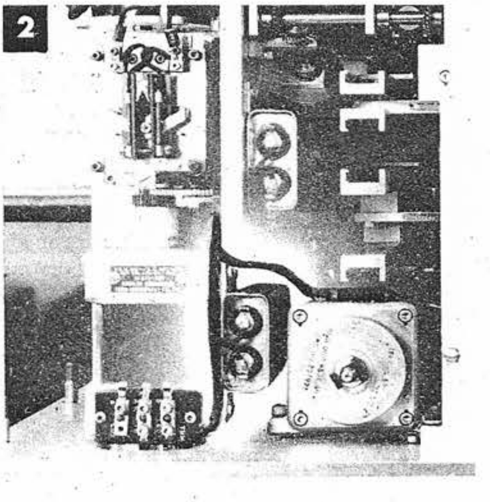
Readjust the star shell computer to the instrument.

RANGE MOTOR

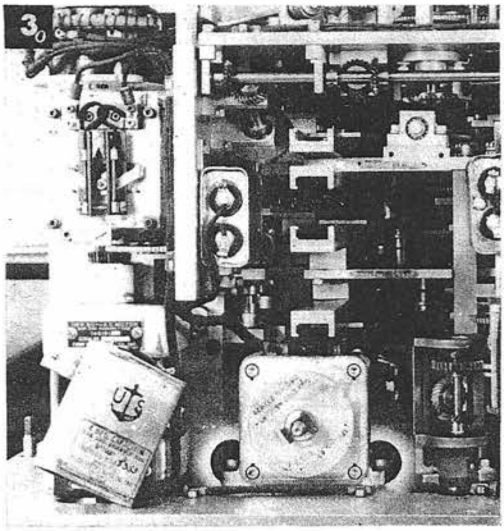




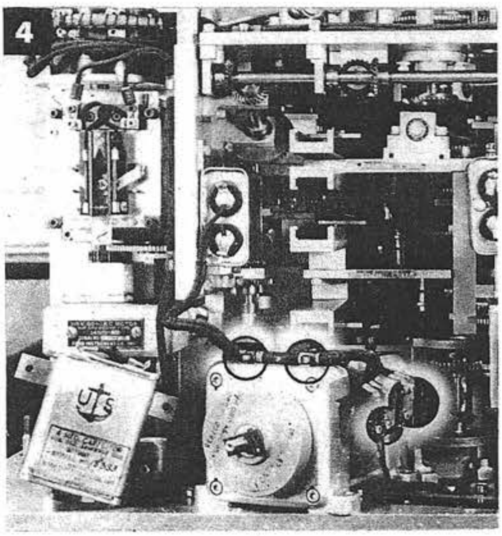
1 Remove the five screws securing the supporting post beside the range motor.



2 Remove the two screws securing the capacitor brackets to the time motor.

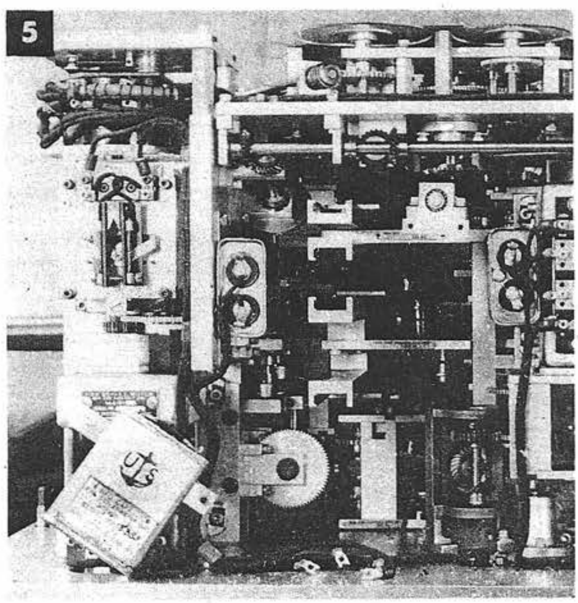


3 Remove the four screws securing the range motor to the base plate.



4 Lift the range motor over the cable in front of it.
Remove the screws connecting the external leads to the terminal block.
Remove the two screws securing the terminal block. Free the leads.
Remove the screws from the two cable clamps on the motor. Free the cable.

5 Remove the motor.



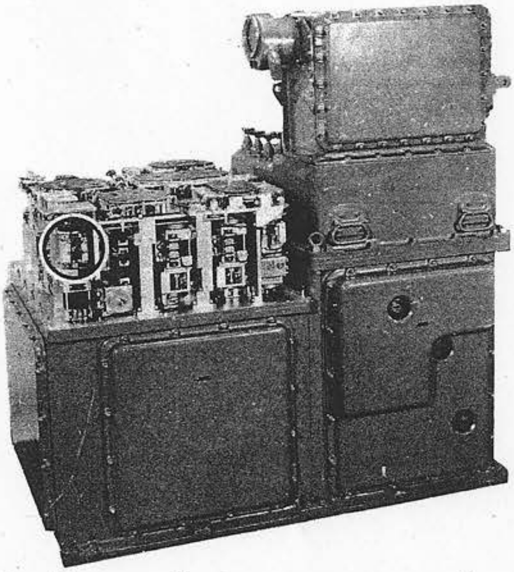
To reinstall the range motor, reverse the removal procedure.

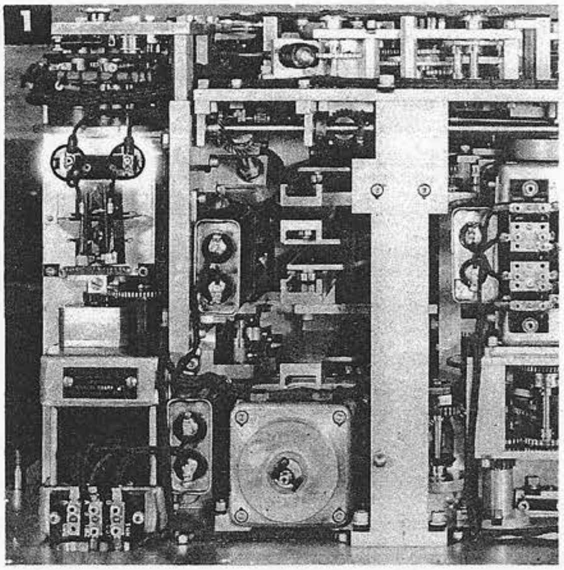
CAUTION: Tighten clamp A-168 on the motor shaft. It cannot be reached after the motor is installed.

Check the operation of the range receiver.

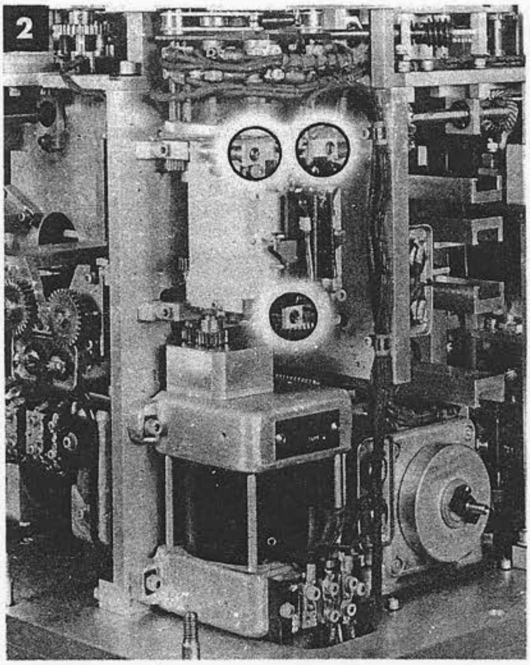
Gene Slover's US Navy Pages | Table of Contents

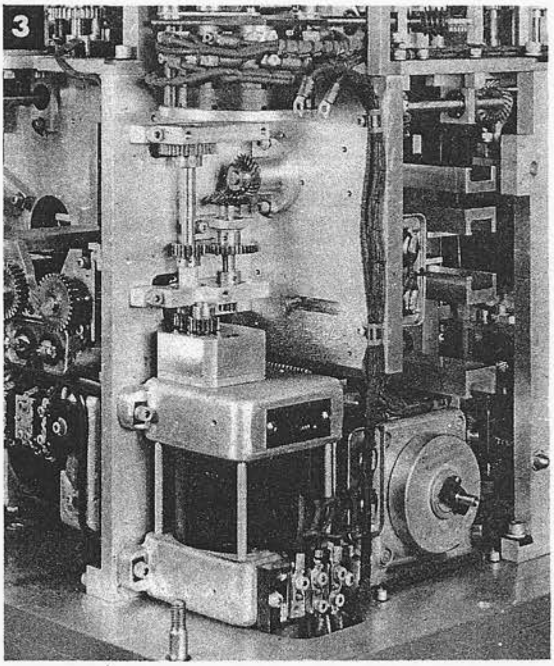
TIME MOTOR REGULATOR





1 Remove the two screws connecting cable leads TMR and TM2 to the terminal block on the time motor regulator.





2 Loosen the three camera screws securing the regulator to the mounting brackets.
Tilt the gear end of the regulator out of mesh.

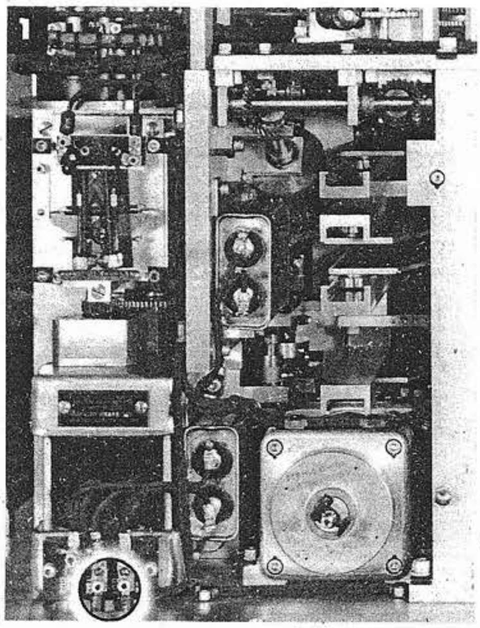
3 Remove the regulator.

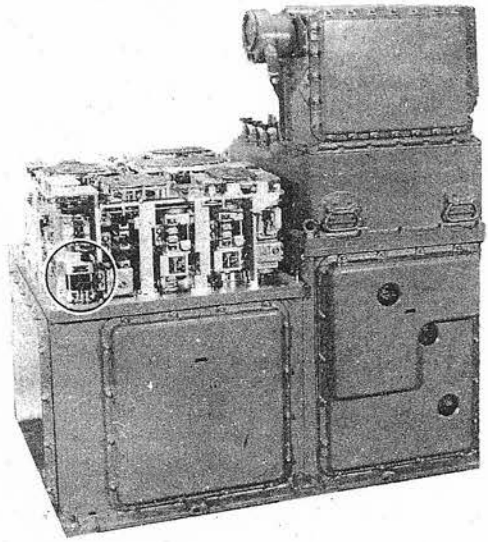
To reinstall the time motor regulator, reverse the removal procedure.

Position the gear on the regulator for sufficient clearance.

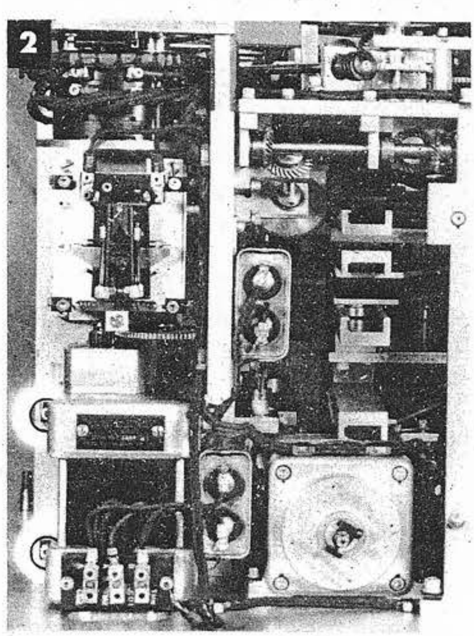
Gene Slover's US Navy Pages | Table of Contents

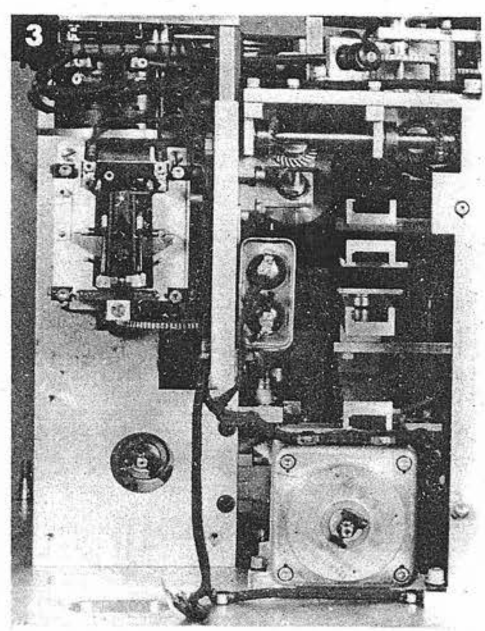
TIME MOTOR





1 Remove the two screws connecting cable leads TMM and TM2 to the servo-motor terminal block.

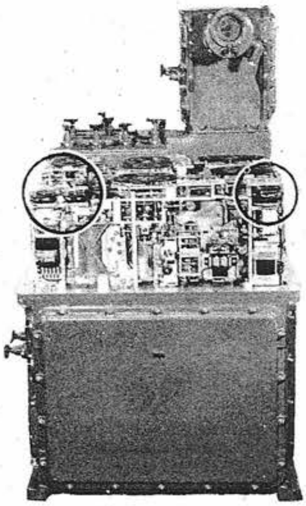




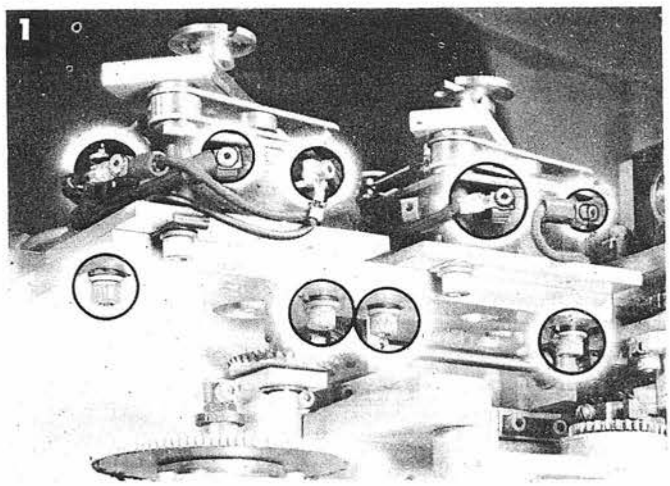
2 Remove the four screws securing the motor to the mounting plate.

3 Remove the motor.

To reinstall the time motor, reverse the removal procedure.

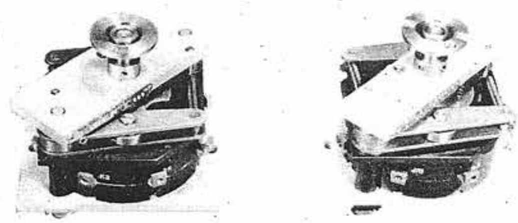


TARGET SPEED, RANGE RATE CONTROL, AND CONTROL SWITCHES

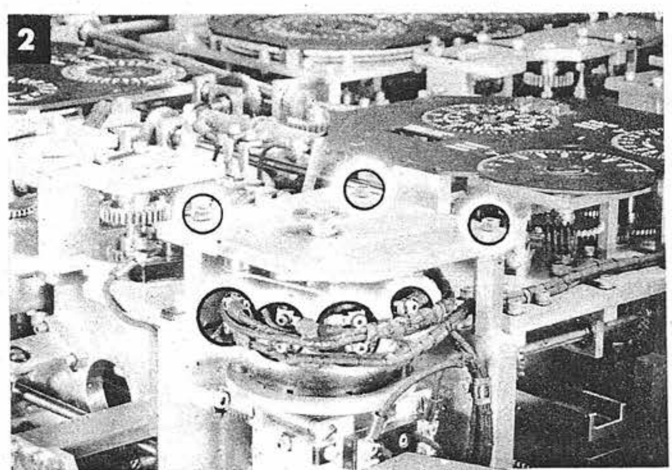


NOTE:
Label any unflagged cable leads so that they can be correctly reconnected.

1 To remove the target speed or the range rate control switch, remove the two screws securing the switch to the mounting plate.
Remove all the screws connecting the cable leads to the switch. Remove the switch.



2 To remove the control switch, remove the three screws securing the mounting plate to the instrument.
Remove all the screws connecting cable leads to the switch. (See note above.) Remove the switch.

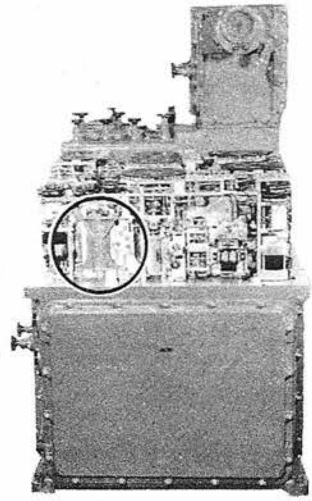


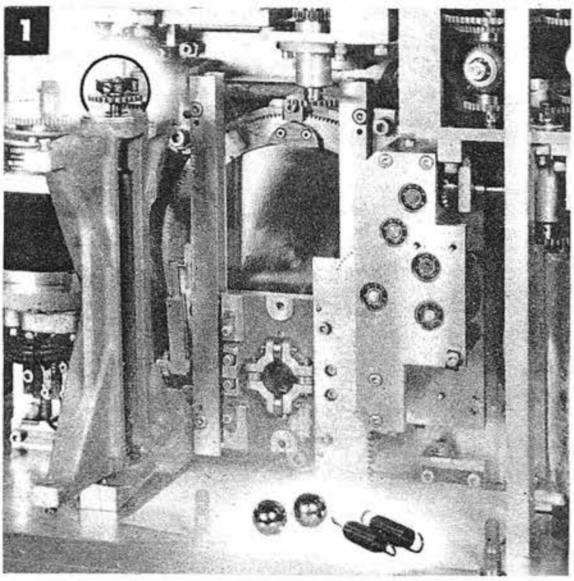
To reinstall a switch, reverse the removal procedure.

Check all cable connections before turning the power on.

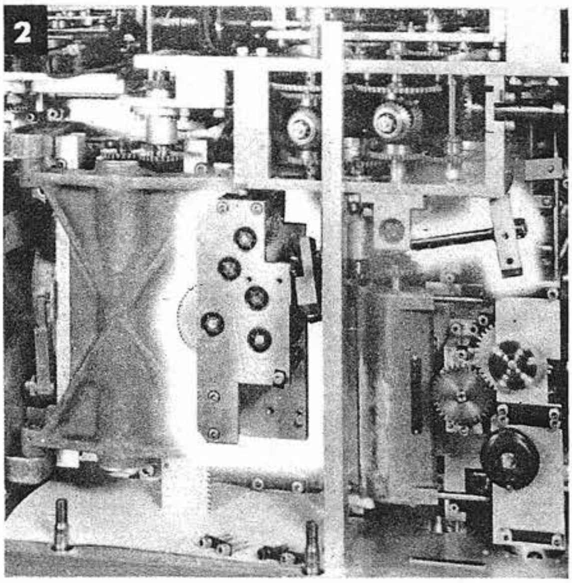
Gene Slover's US Navy Pages | Table of Contents

RANGE RATE INTEGRATOR





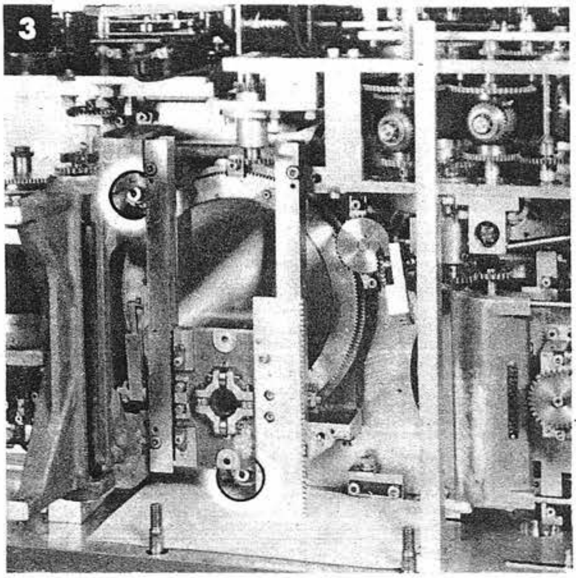
1 Loosen clamp A-167 and slip the gear out of mesh. Remove the two springs. Open the integrator. Be careful not to drop the balls. Remove both balls from the retaining rollers.



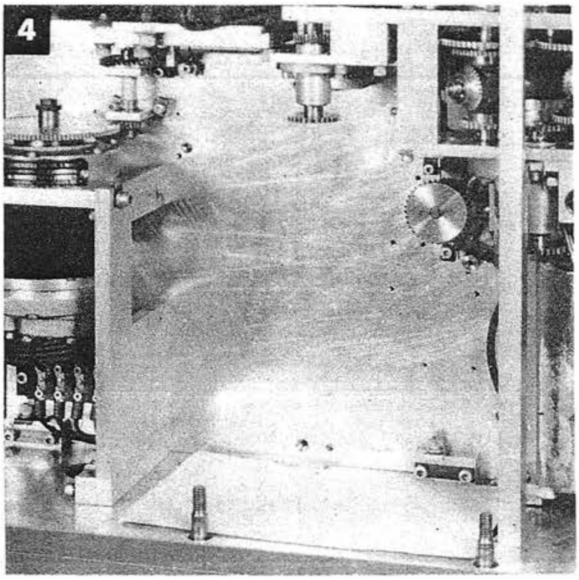
2 Remove the four screws securing the horizontal shaft assembly above the range rate ratio integrator. It is not necessary to remove this shaft assembly.
Remove the three rear screws securing the gearing at the right of the range rate integrator. Remove the gearing group.

Gene Slover's US Navy Pages Table of Contents

3 Remove the three screws securing the integrator to the plate. Work the dowels free.



4 Remove the range rate integrator.



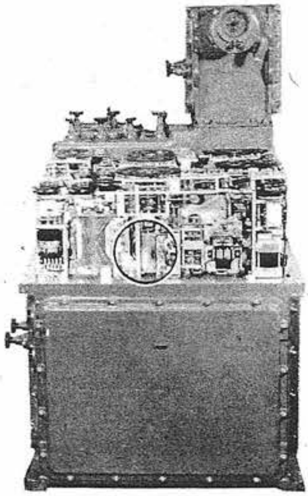
To reinstall the range rate integrator, reverse the removal procedure.

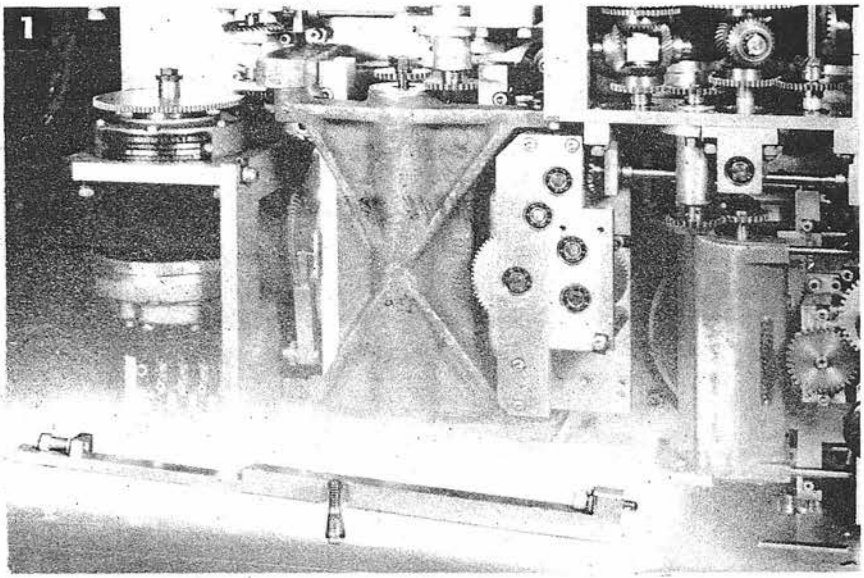
Readjust clamps A-170 and A-171.

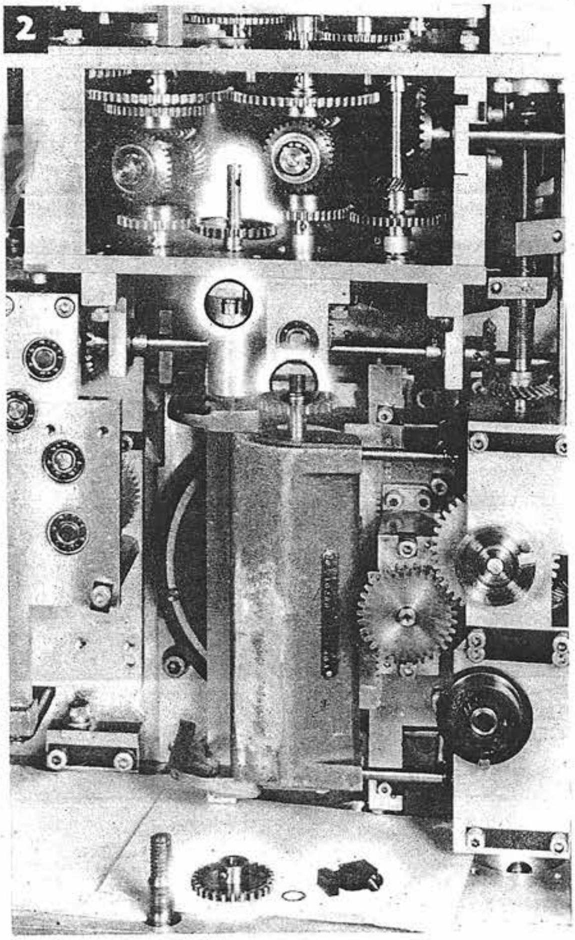
Run tests.

Gene Slover's US Navy Pages | Table of Contents

RANGE RATE RATIO INTEGRATOR

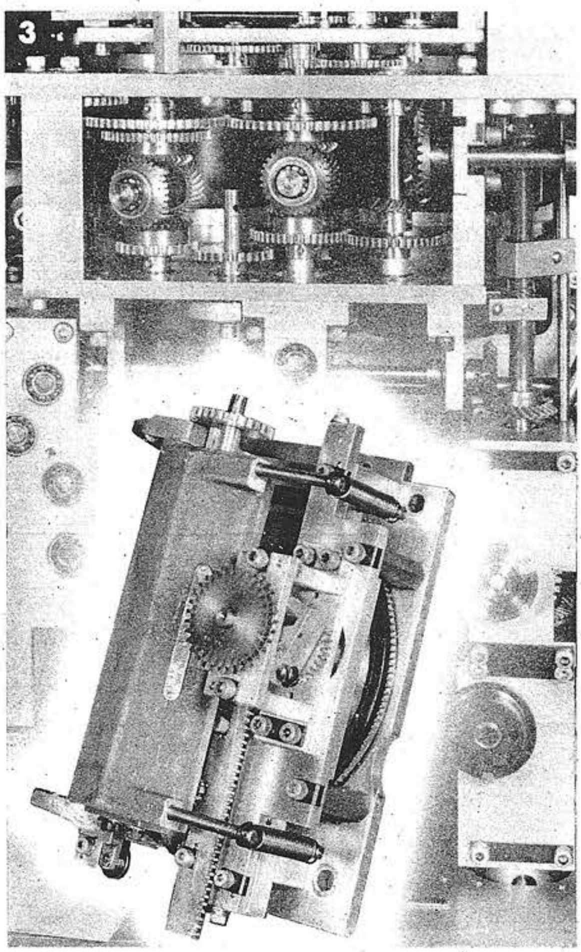


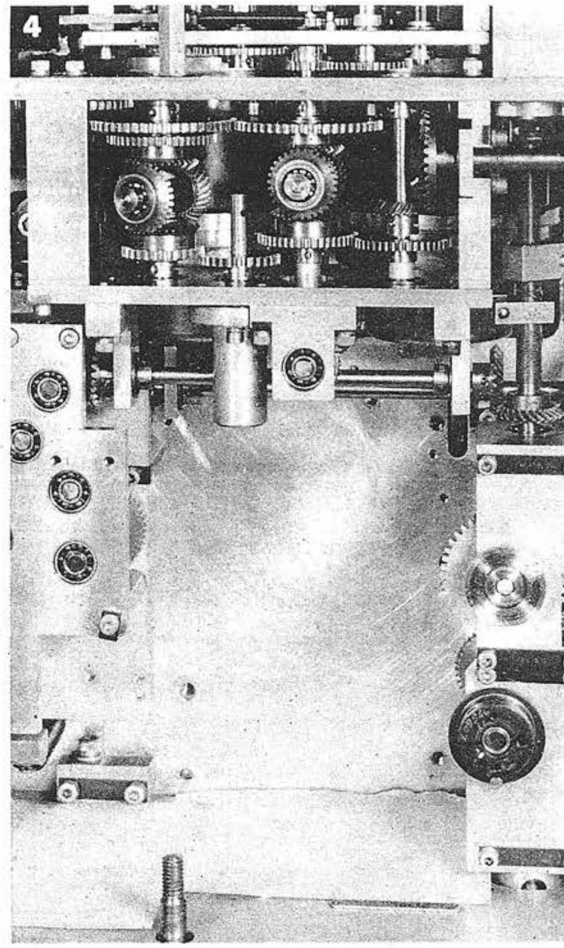




1 Remove the two screws securing the supporting post in front of the integrator. Remove the post.
Place paper over the holes in the plate below the integrator to prevent parts from falling through.

2 Unpin the two gears on the shaft assembly to the left of the integrator output. Push the shaft up through the gears and adapter until the lower of the two gears can be removed. Loosen, but do not remove, the two screws securing the adapter.
Remove clamp A-166.





3 Remove the three screws securing the integrator to the plate. Work the dowels free. Tilt the integrator to clear the gearing.

4 Remove the range rate ratio integrator.

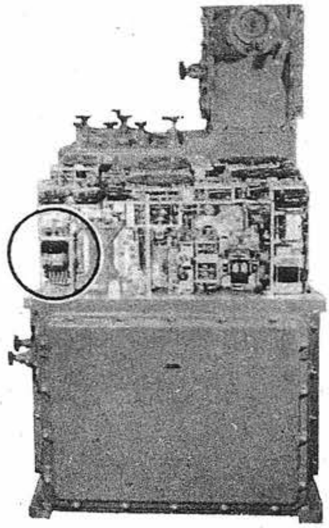
To reinstall the range rate ratio integrator, reverse the removal procedure.

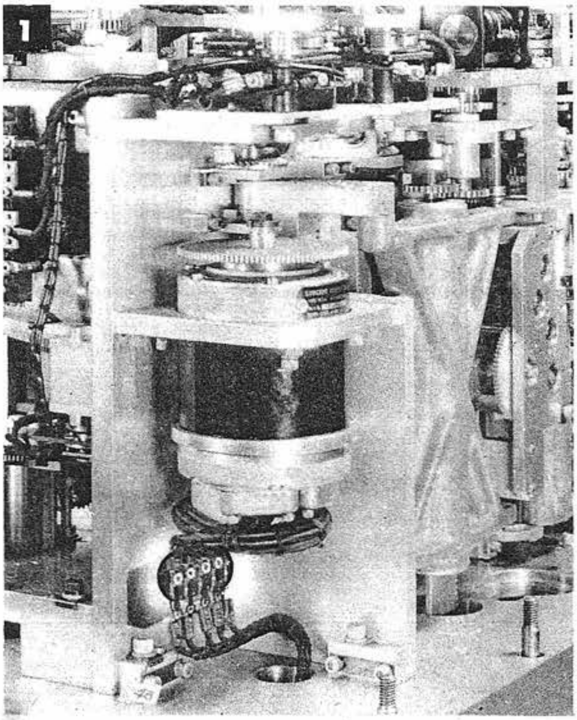
Readjust clamps A-172 and A-173.

Run rate control tests.

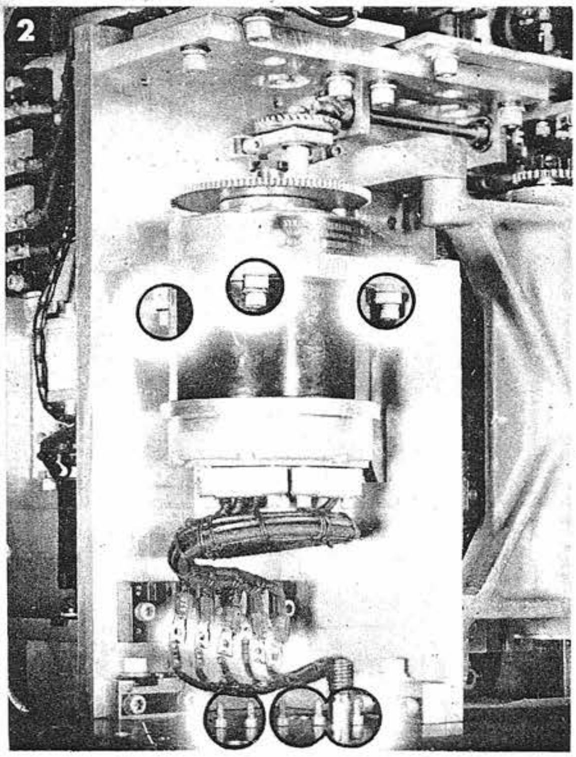
Table of Contents

△cR TRANSMITTER





1 Remove the five screws connecting the transmitter leads to the terminal block.

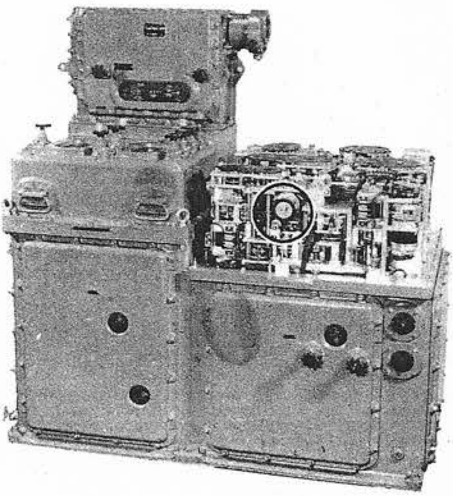


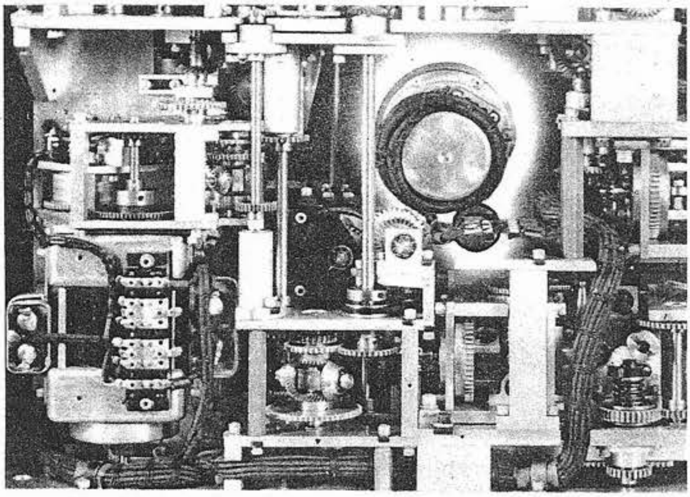
2 Remove the three screws and locking blocks securing the transmitter. Remove the transmitter.

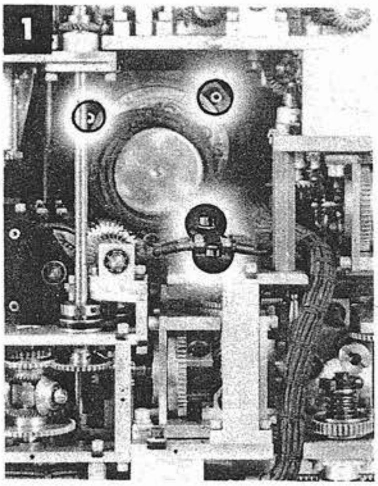
To reinstall the △*cR* transmitter, reverse the removal procedure.

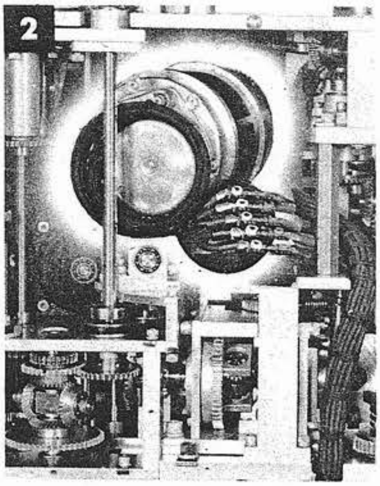
Run transmission tests.

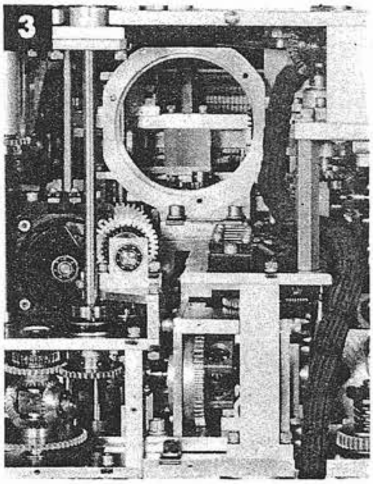
Ct TRANSMITTER











1 Remove the three screws and locking blocks securing the transmitter.
Remove the two screws securing the terminal block.

2 Remove the five screws connecting the transmitter leads to the terminal block.

3 Remove the transmitter.

To reinstall the *Ct* transmitter, reverse the removal procedure.

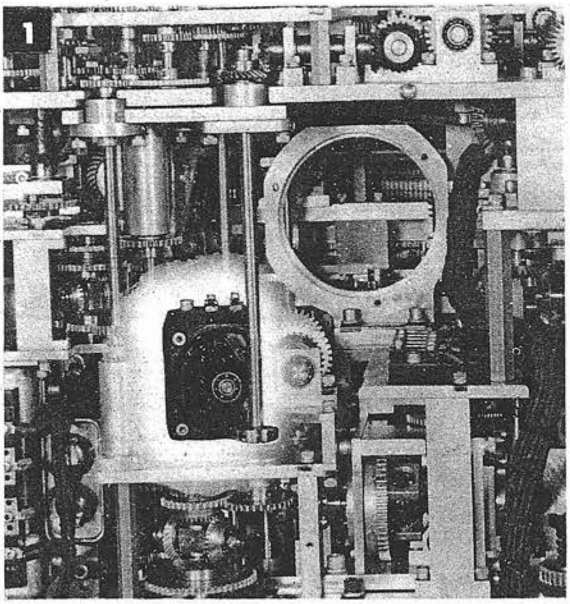
Readjust clamp A-258.

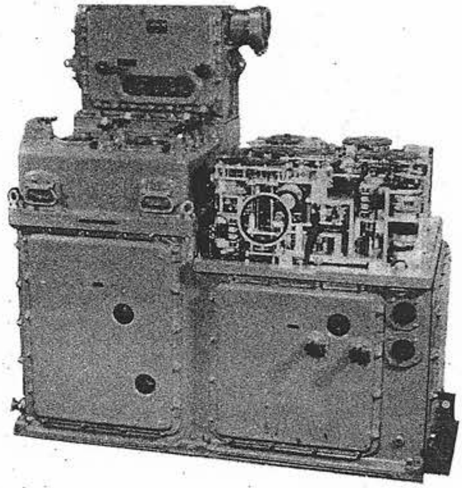
Run transmission tests.

Table of Contents

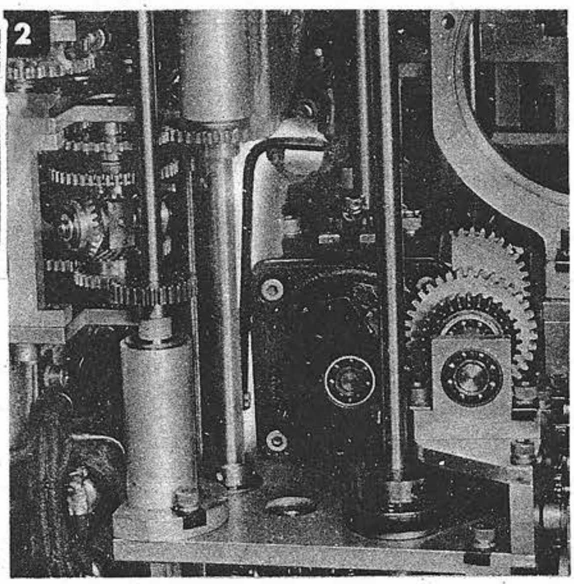
jdR CLUTCH

Ct Transmitter, page 611

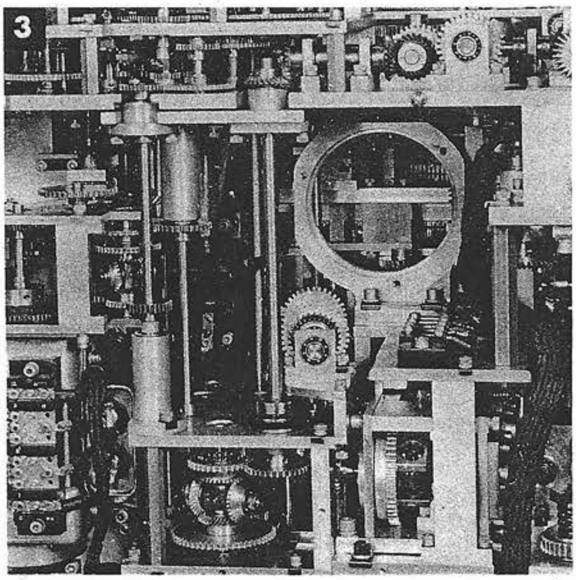




1 Remove the two screws connecting the cable leads jRR and jR1 to the clutch terminal block.



2 Remove the two screws securing the clutch.



3 Turn the clutch to clear the gearing. Remove the *jdR* clutch.

To reinstall the *jdR* clutch, reverse the removal procedure.

Reinstall the *Ct* transmitter.

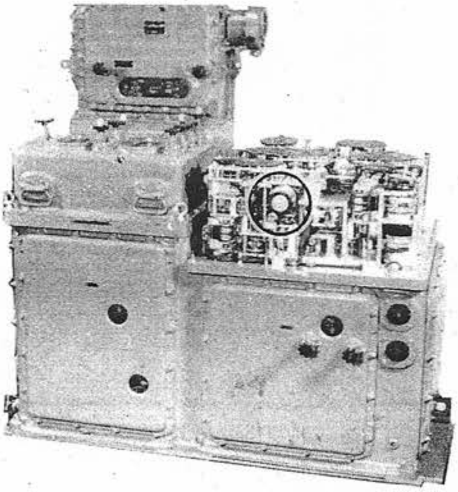
Readjust clamp A-258.

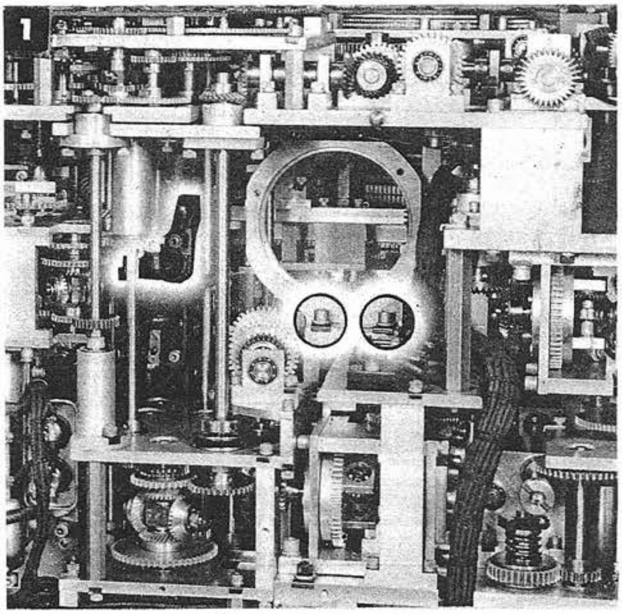
Check rate control and transmission tests.

Gene Slover's US Navy Pages | Table of Contents

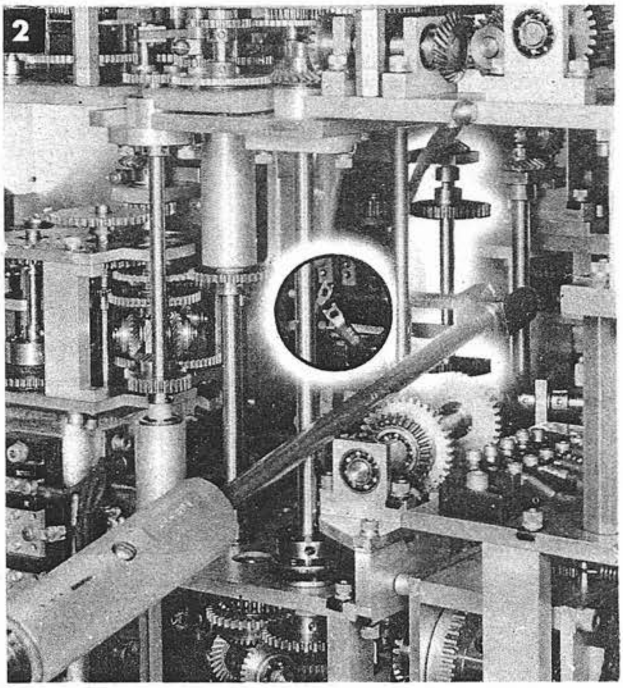
jE LOCK

Ct Transmitter, page 611
jdR Clutch, page 612

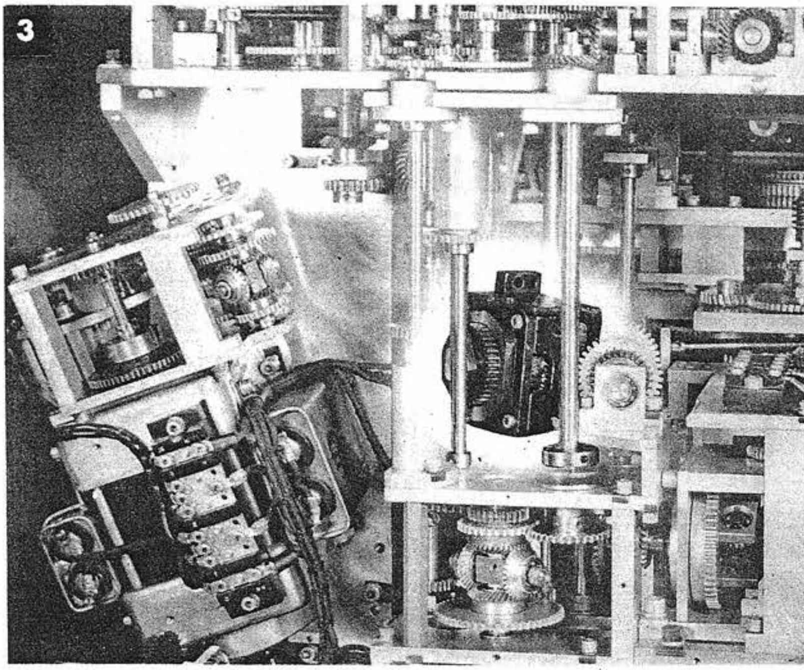




1 Remove the two screws securing the mounting bracket for the *Ct* transmitter. Remove the bracket.
Remove the two screws connecting cables NLC and NLCC to the terminal block of the lock.



2 Remove the four screws securing the shaft assembly between the lock and the *jE* clutch below the lock. Remove the assembly.
Remove the two screws securing the lock.



3 Remove the four screws securing the *jE* servo motor to the mounting plate. Tilt the follow-up out of the way. Turn the lock to clear the surrounding gearing. Remove the lock.

To reinstall the *jE* lock, reverse the removal procedure.

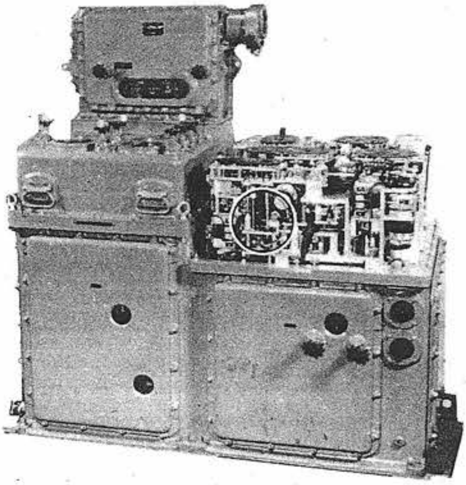
Reinstall the *jdR* clutch and the *Ct* transmitter.

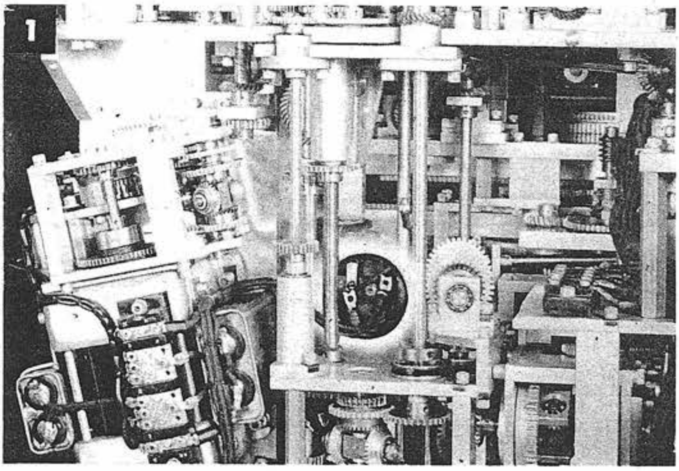
Readjust clamps A-258 and A-259. Run rate control and transmission tests.

Gene Slover's US Navy Pages | Table of Contents

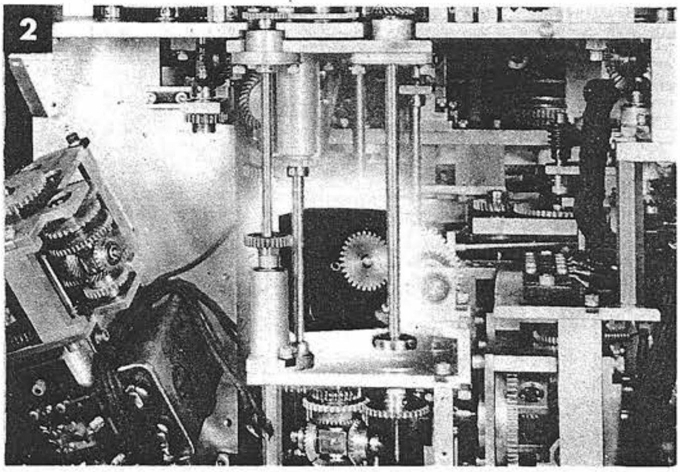
jE CLUTCH

Ct Transmitter, page 611
jdR Clutch, page 612
jE Lock, page 613



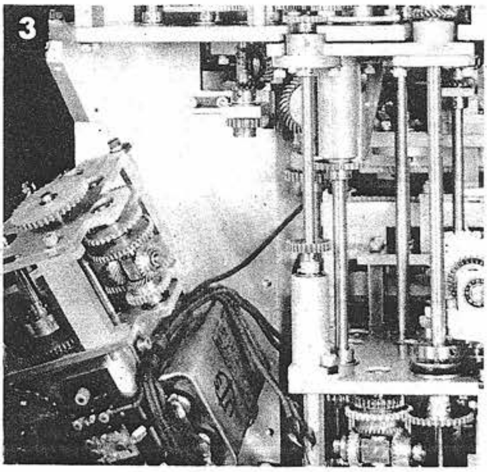


1 Remove the two screws connecting cable leads NC and NCC to the terminal block. Remove the two screws securing the clutch to the mounting plate.



2 Turn the clutch almost completely around to clear the gearing.

3 Remove the *jE* clutch.



To reinstall the *jE* clutch, reverse the removal procedure.

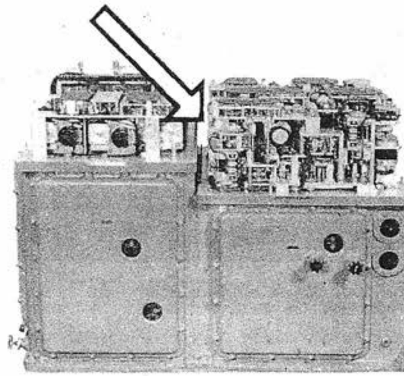
Reinstall the *jE* lock, the *jdR* clutch, and the *Ct* transmitter.

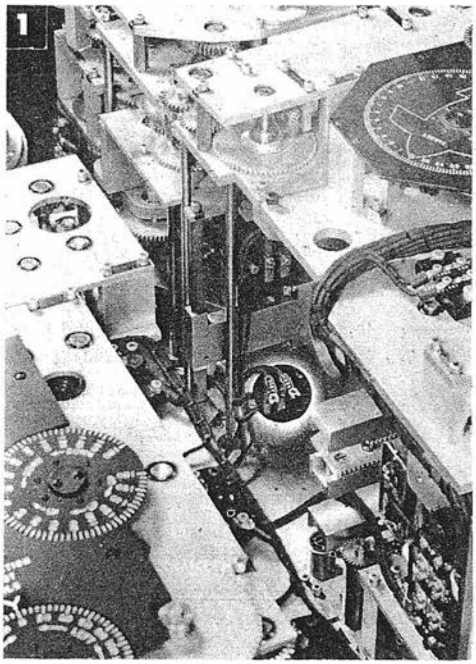
Readjust clamps A-258 and A-529.

Run tests.

jBr LOCK

RdE Follow-up, page 597

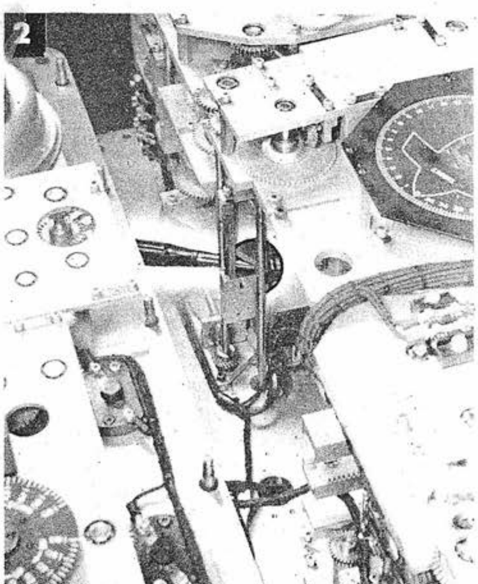


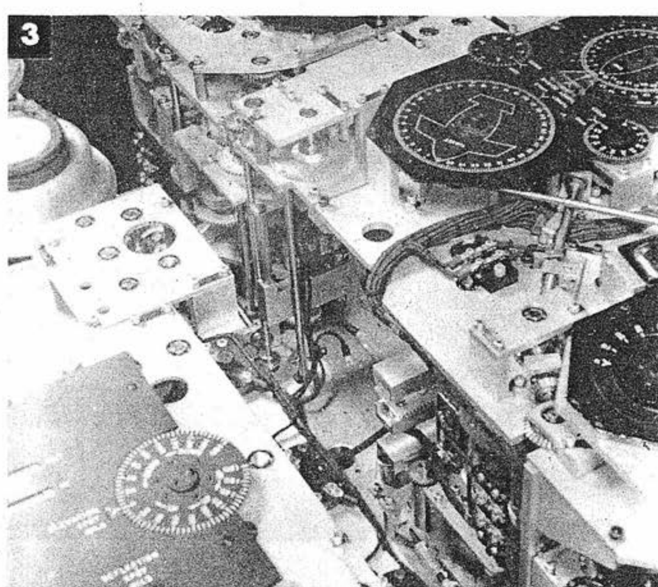


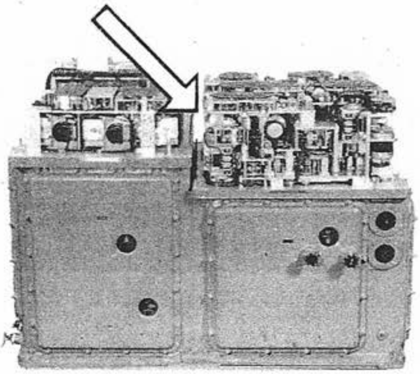
1 Remove the two screws connecting cable leads TLC and TLCC to the terminal block.
Remove the screw from the cable clamp on the lock. Free the cable.

2 Remove the two screws securing the lock. The screw at the right is always a fillister type screw.

3 Remove the *jBr* lock.

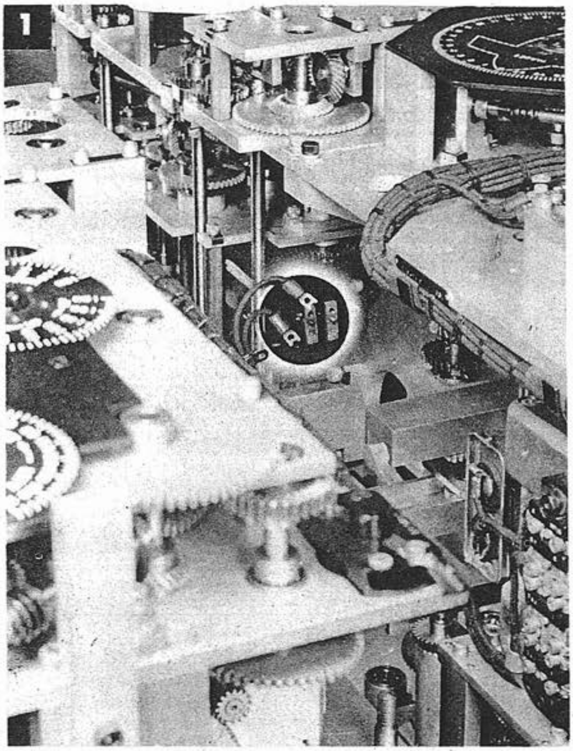




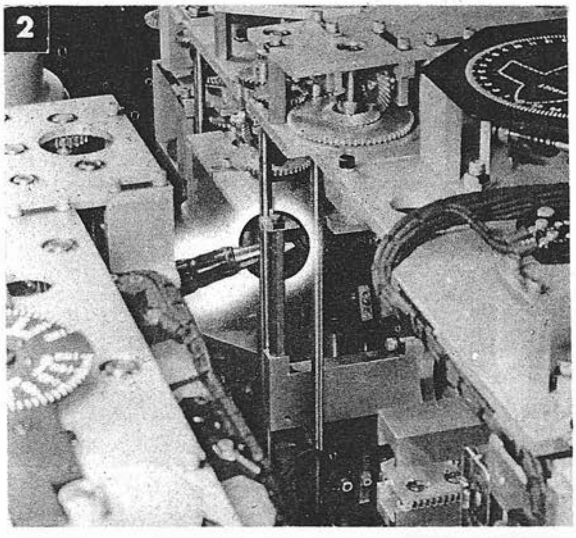


jBr CLUTCH

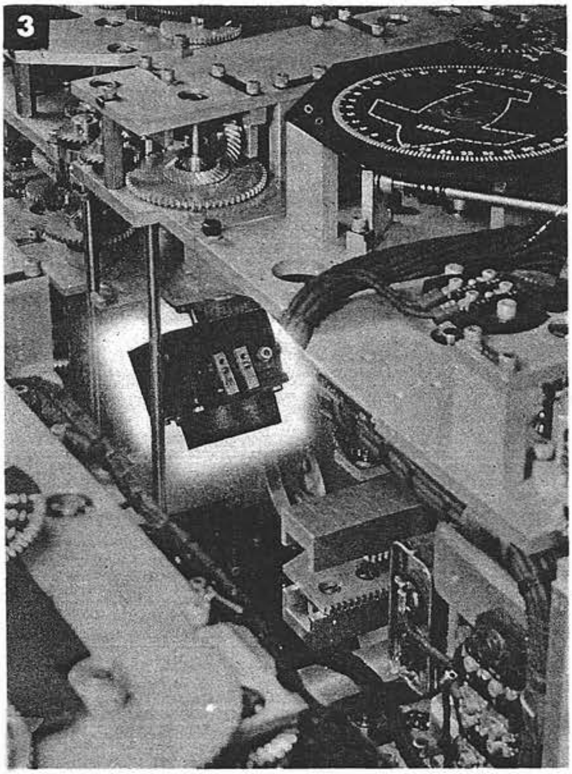
RdE Follow-up, page 597

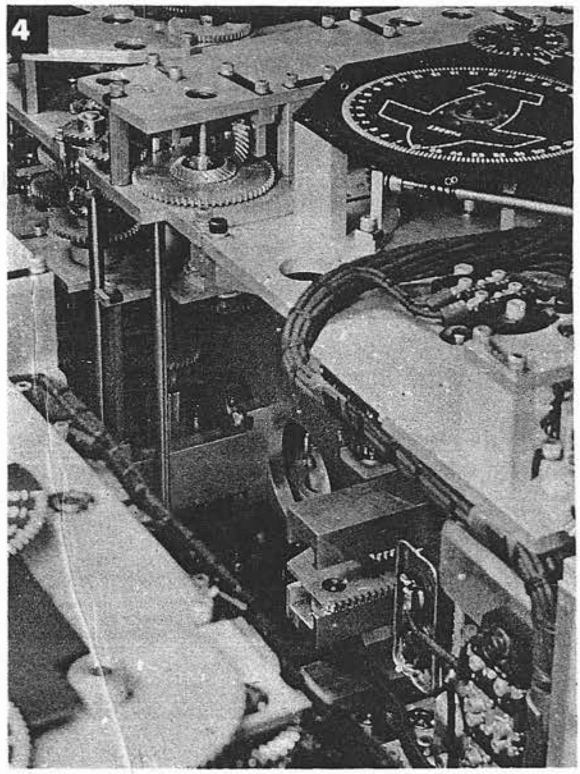


1 Remove the two screws connecting cable leads TC and TCC to the terminal block.
Remove the screw securing the cable clamp to the clutch. Free the cable.



2 Remove the two screws securing the clutch. The screw at the right is always a fillister type screw.





3 Loosen clamp A-207. Slip the gear up out of mesh as far as it will go. Tilt the clutch to clear the shafts.

4 Remove the *jBr* clutch.

To reinstall the *jBr* clutch, reverse the removal procedure.

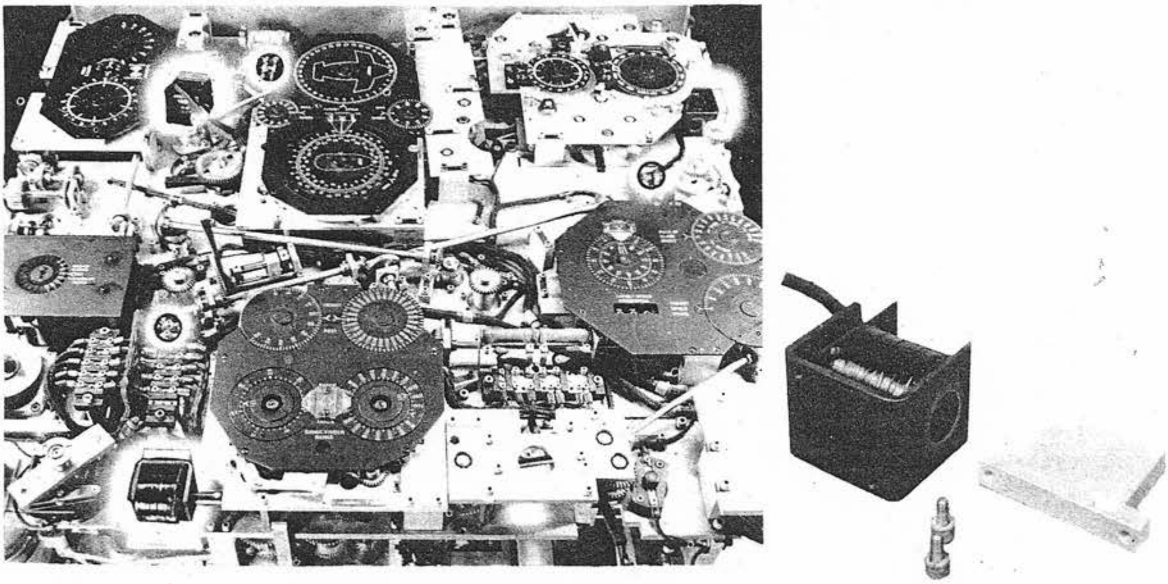
Reinstall the *RdE* follow-up.

Readjust clamp A-118.

Run tests.

Gene Slover's US Navy Pages | Table of Contents

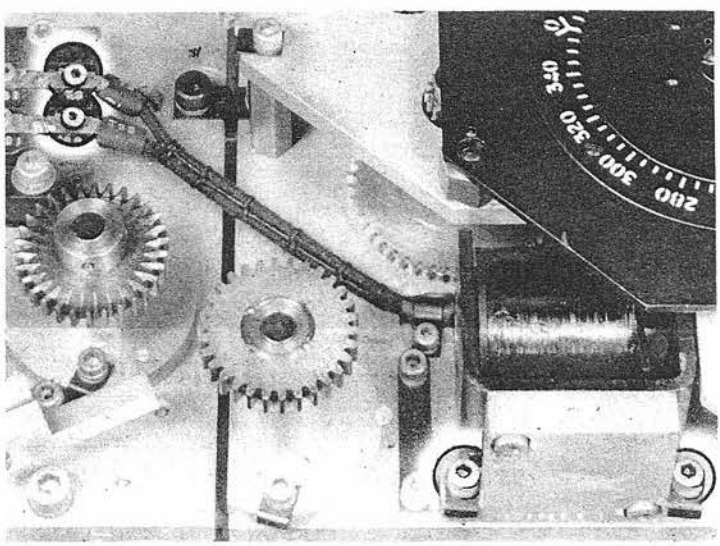
RANGE FINDER'S, POINTER'S, AND TRAINER'S SIGNAL SOLENOIDS



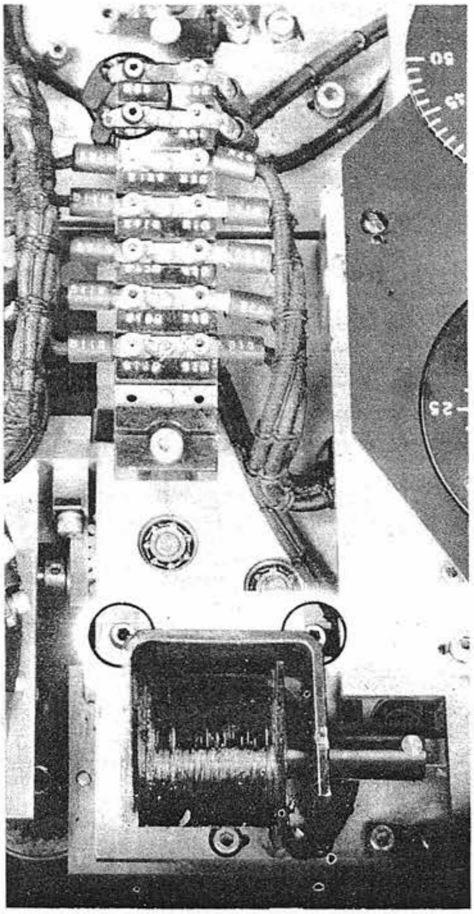
To remove any one of the signal solenoids, remove the two screws connecting its cable leads to the terminal block. Also remove the two screws securing the coil hanger to the top plate of the computer. Tilt the coil to disengage the plunger.

TRAINER'S SIGNAL

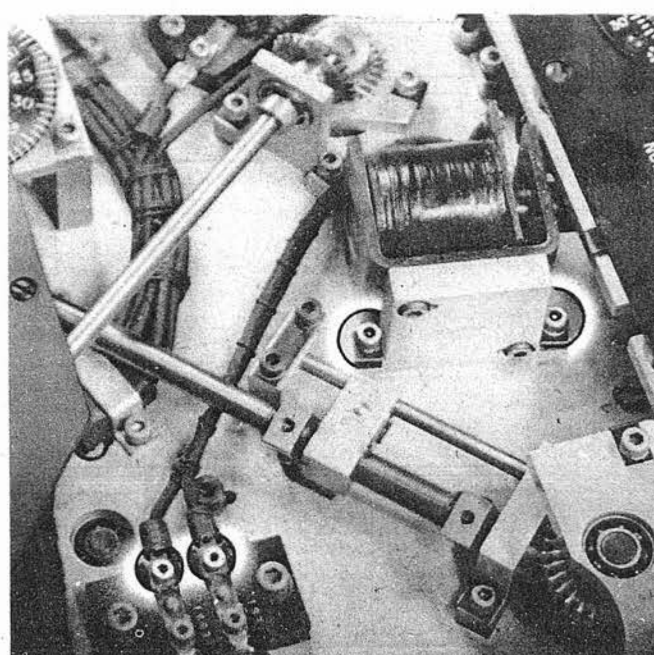
Disconnect leads TS and TSS.



RANGE FINDER'S SIGNAL



Disconnect leads RS and RSS.

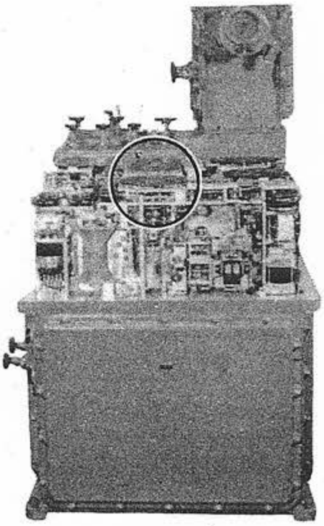


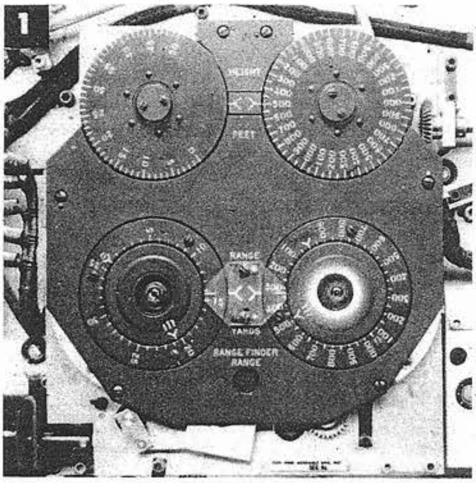
POINTER'S SIGNAL

Disconnect leads ES and ESS.

To reinstall a signal solenoid, reverse the removal procedure. Before tightening the screws firmly, energize the solenoid and position the coil so that the plunger does not hum or vibrate within the coil.

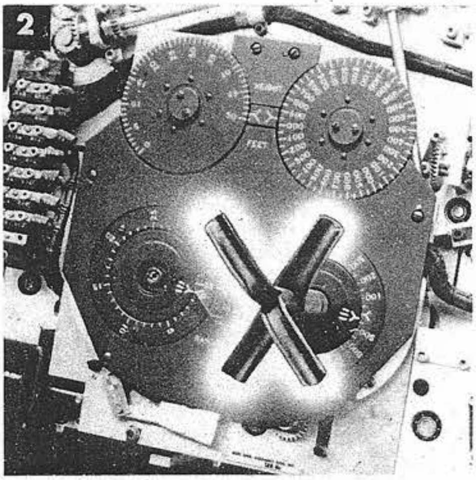
RANGE RECEIVER



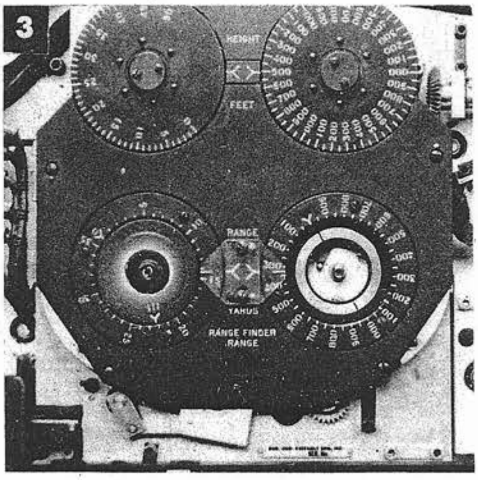


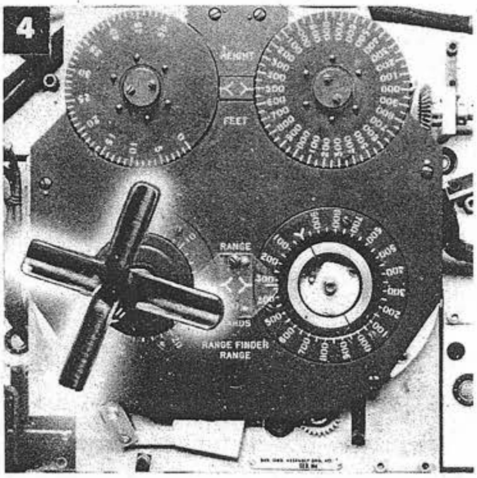
1 Loosen the nut securing the fine inner range dial to the rotor shaft.

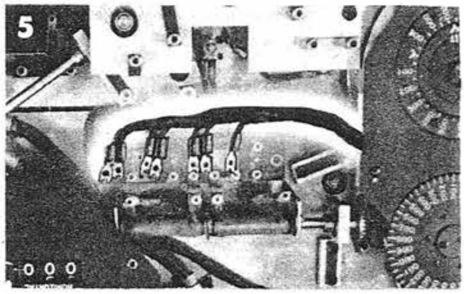
2 Using a special dial wrench, remove the nut and washer. Remove the dial.



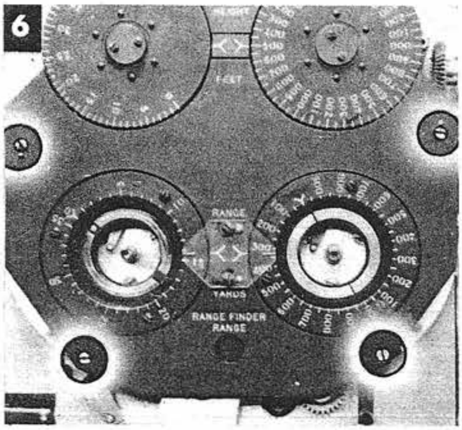
3 In the same manner, remove the coarse inner range dial.



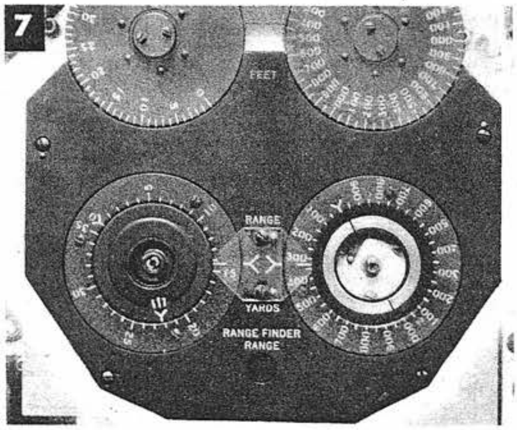




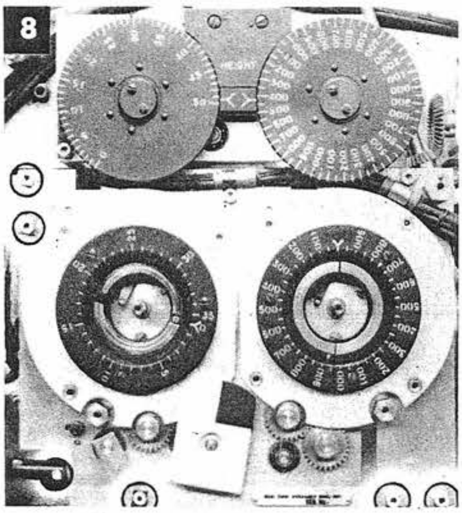
5 Remove the seven screws connecting cable leads to the terminal block at the right of the range receiver.



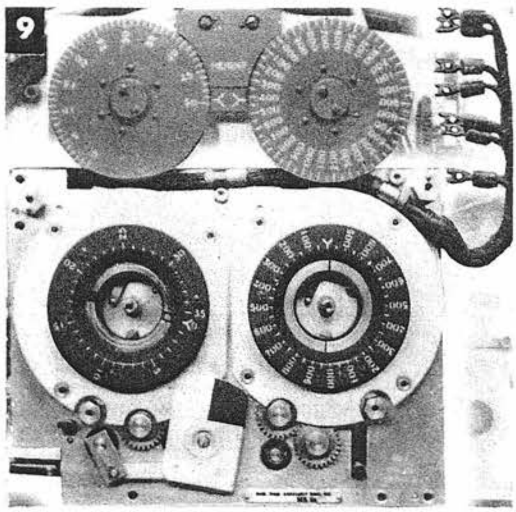
6 Remove the four screws securing the mask over the range receiver.



7 Remove the mask. Do not damage the dowels.

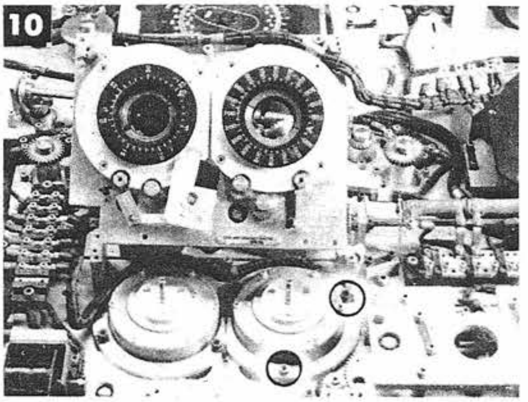


8 Remove the six screws securing the range receiver gearing. One screw is hidden below the cable at the upper right.
Remove the cotter pin from the pivot stud at the end of the solenoid plunger. Free the plunger arm.

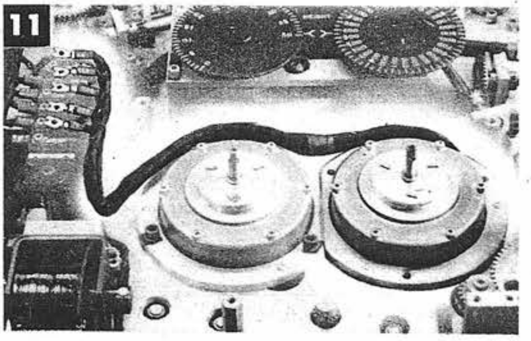


9 Work the unit dowels free. To avoid bending the height dials, lift the front edge of this assembly first.
Remove the assembly.

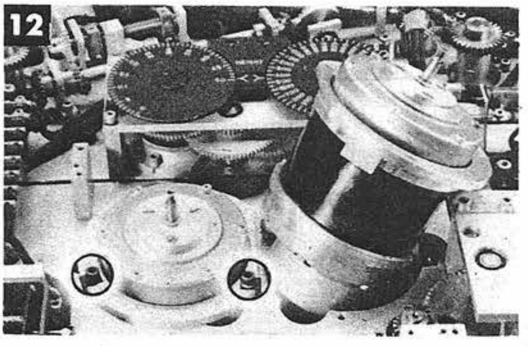
10 To remove the fine synchro, remove the three screws securing the flange to the plate.

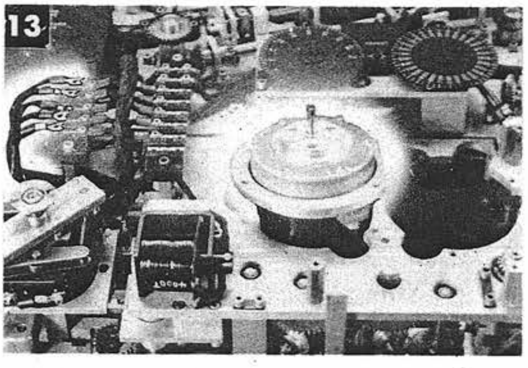


11 Remove the five screws connecting cable leads to the terminal block at the left.
Remove the cable clamp behind the synchros. Remove the fine synchro.



12 To remove the coarse synchro, remove the three screws securing the flange to the plate.



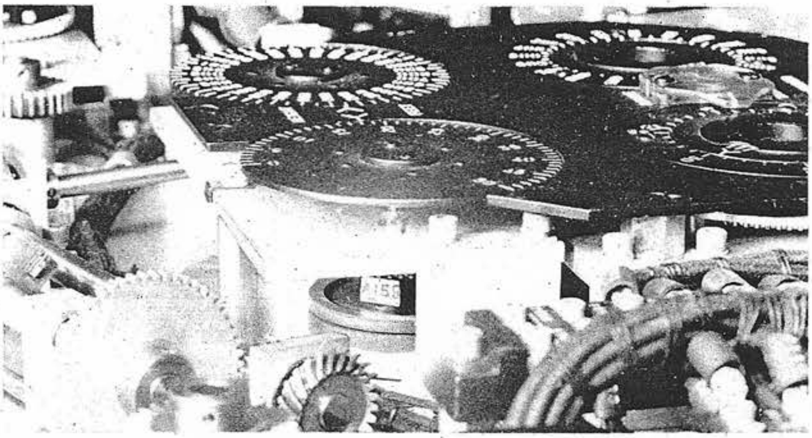


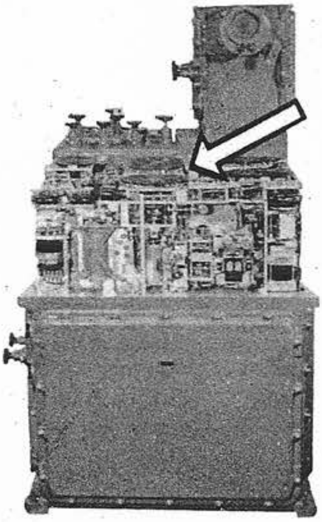
13 Remove the five screws connecting leads to the terminal block at the left.
Remove the synchro. Pull the cable through.

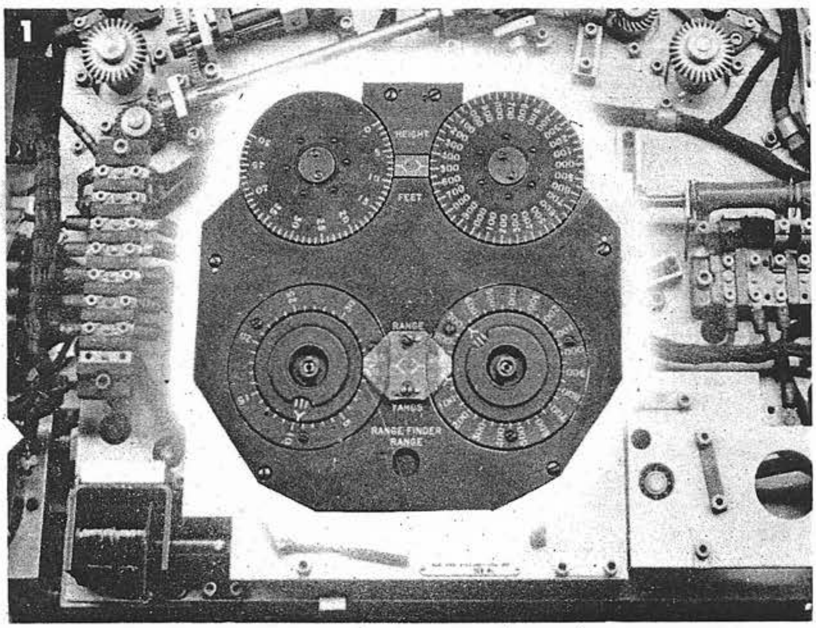
To reinstall the range receiver, reverse the removal procedure.

NOTE:
The dial with the roller contact is the fine dial.
Readjust clamp A-546, A-545, A-195, A-196, A-520, and A-521.
Check clamp A-240, A-164, A-187 and A-138.
Run tests.
Check range transmission.

HEIGHT SPRING ASSEMBLY



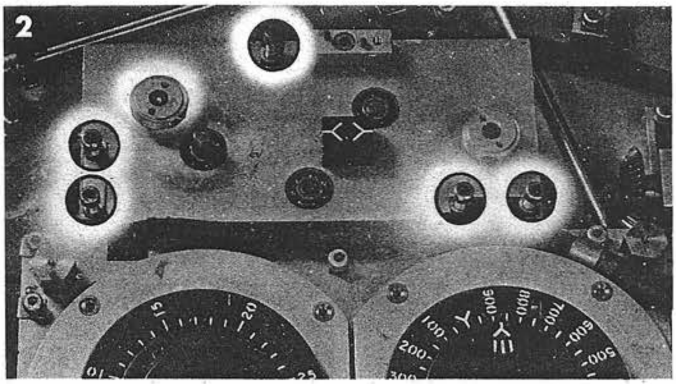




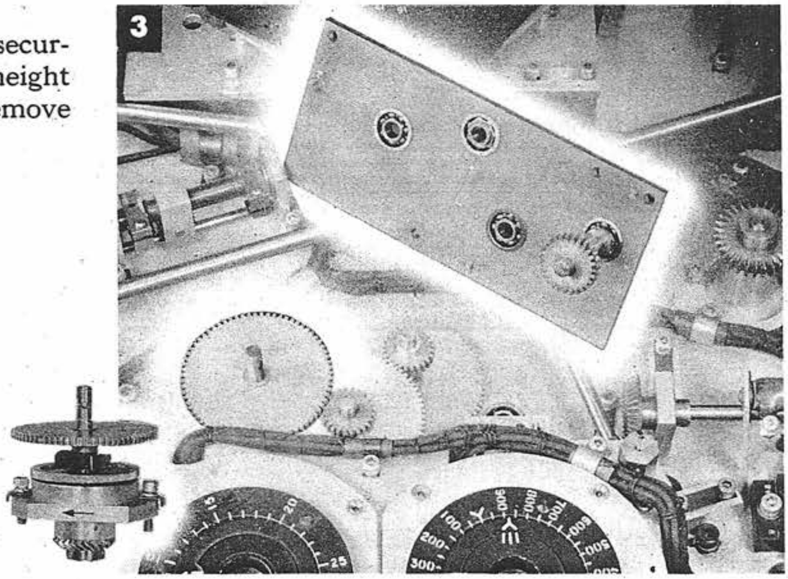
1 Remove the six screws securing the two sections of the masks. Remove both sections.
Remove the dial clamps on the height dials. Remove the dials.

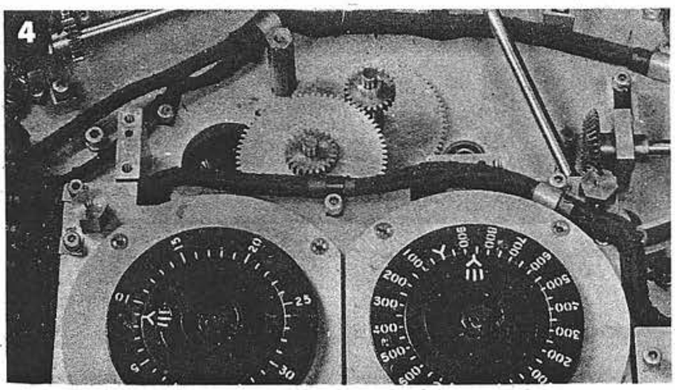
Gene Slover's US Navy Pages | Table of Contents

2 Unpin the coarse dial hub. Remove the hub.
Remove the five screws securing the plate.



3 Remove the plate.
Remove the two screws securing the adapter for the height spring shaft assembly. Remove the assembly.





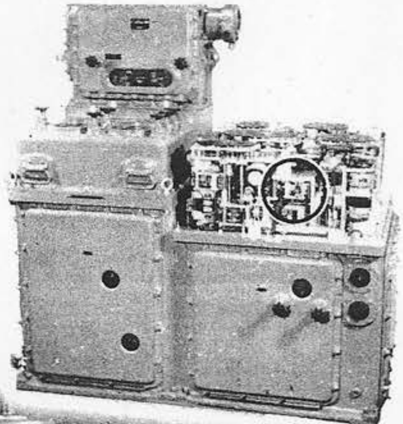
To reinstall the height spring assembly, reverse the removal procedure.

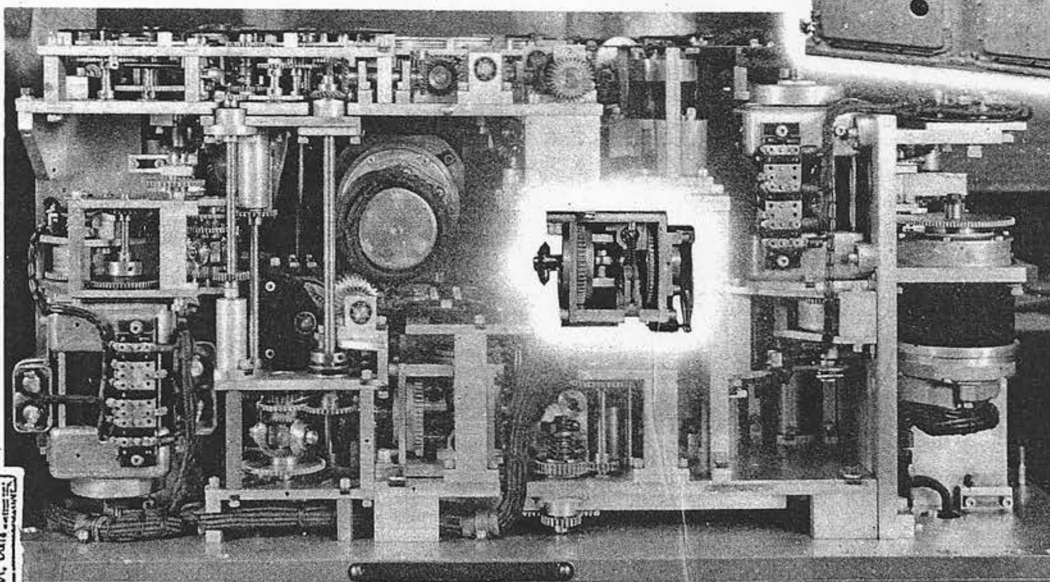
Readjust clamps A-138, A-124, A-158, A-522 and A-523.

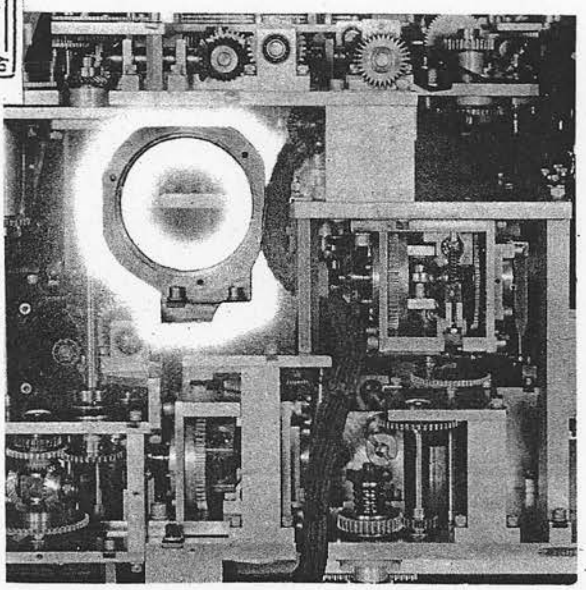
Run tests.

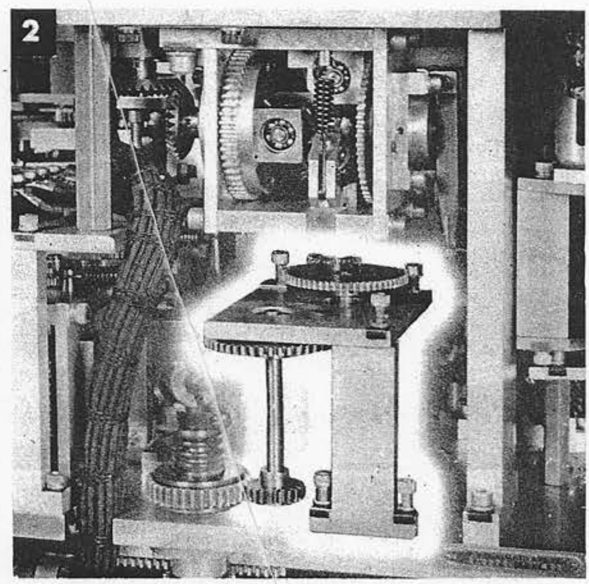
BEARING COMPONENT INTEGRATOR

Ct Transmitter, page 611



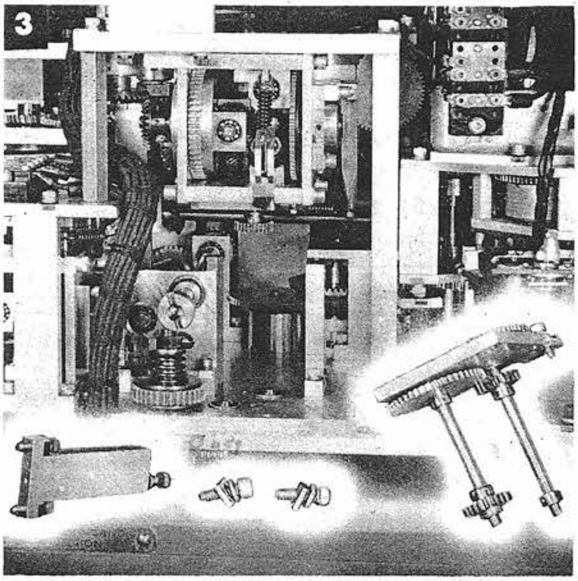




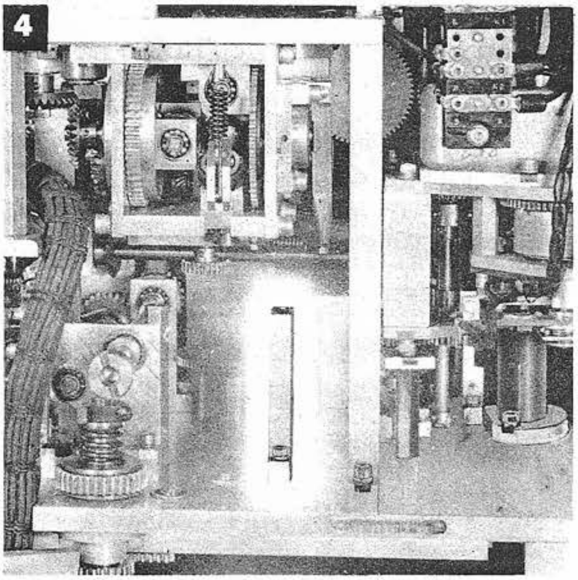


1 Remove the two screws securing the supporting bracket for the *Ct* transmitter.
Remove the bracket.

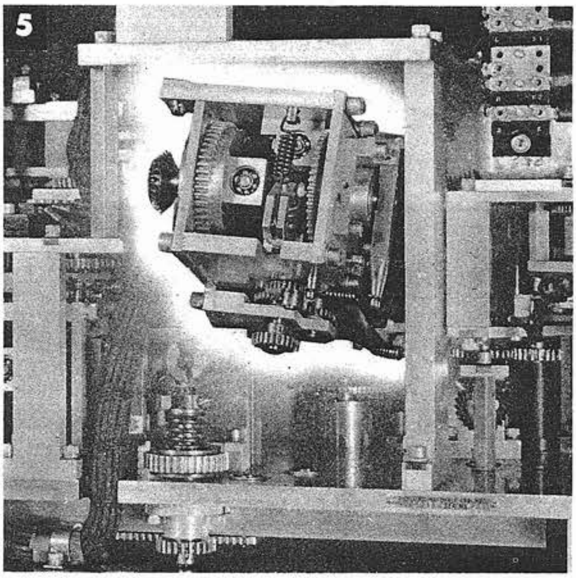
2 Remove the three screws securing the upper plate of the gearing group below the integrator.
Remove the two screws securing the front supporting post.



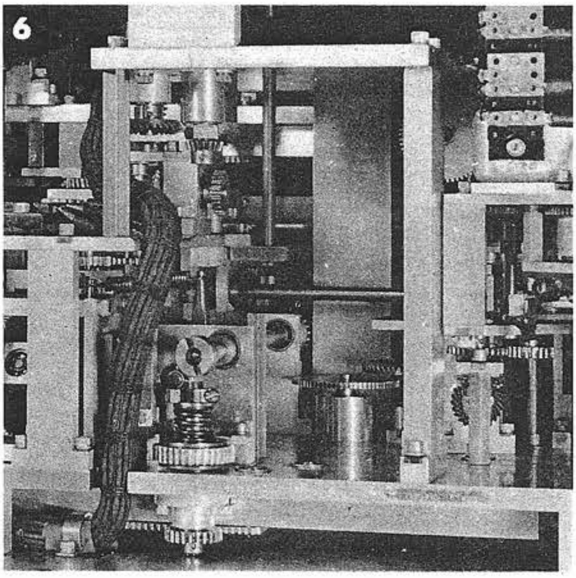
3 Remove the plate, associated shaft assemblies, and the post.



4 Remove the two screws and the rear supporting post for the plate just removed.



5 Back out the two screw dowels at the corners of the integrator toward the rear of the computer. Remove the three screws securing the unit. Support the integrator while removing the last screw. Tilt the integrator to clear the surrounding gearing.



6 Remove the integrator.

To reinstall the mechanism, reverse the removal procedure.

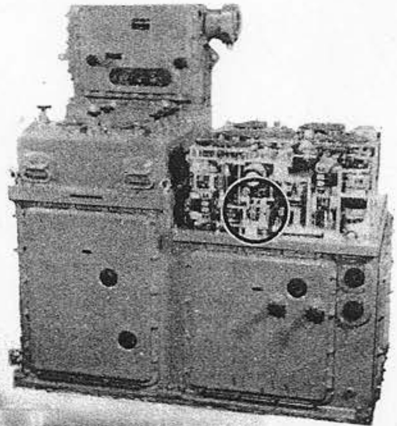
Reinstall the *Ct* transmitter.

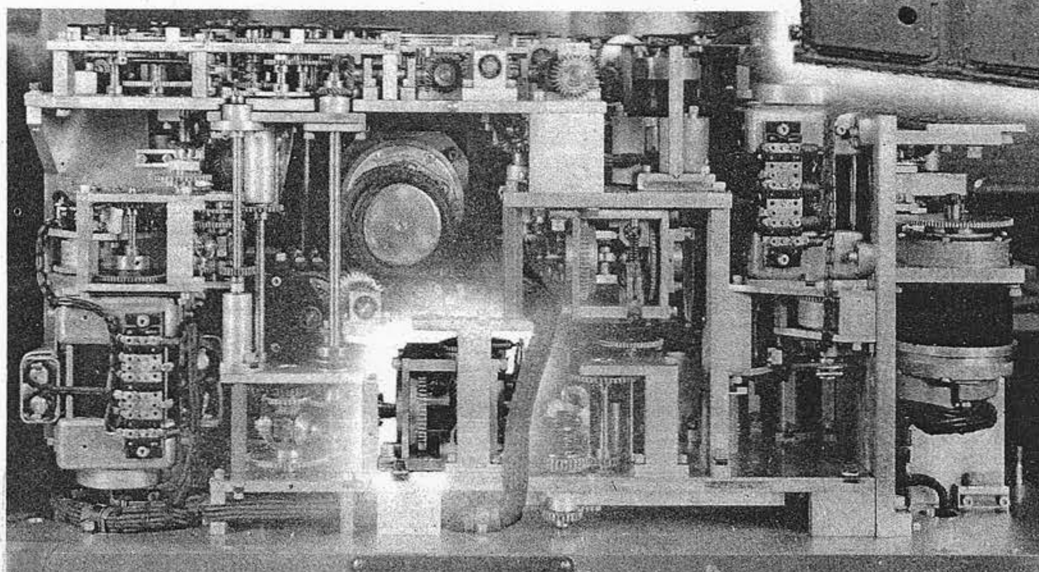
Readjust clamps A-117 and A-258.

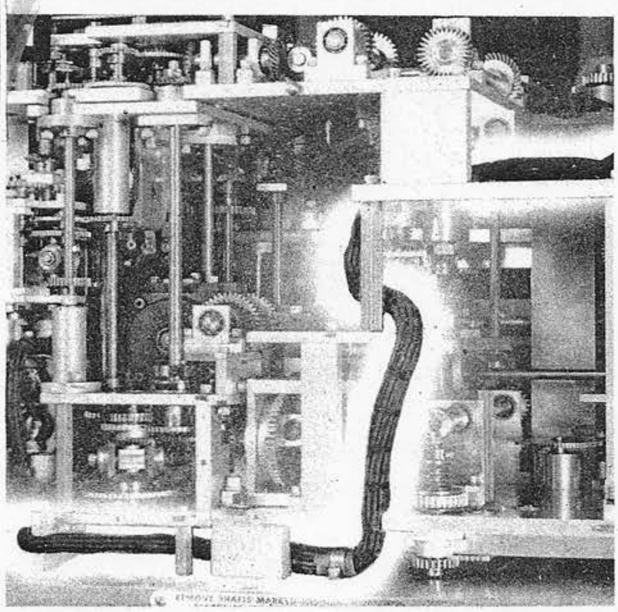
Run rate control and transmission tests.

ELEVATION COMPONENT INTEGRATOR

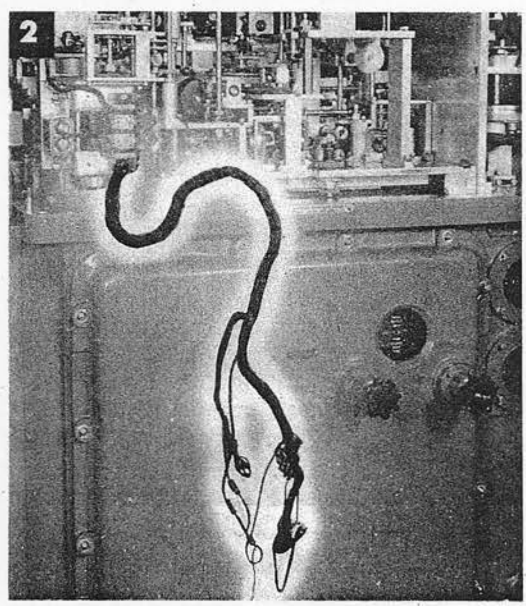
Ct Transmitter, page 611
Bearing Component Integrator, page 626
Sh Follow-up, page 593



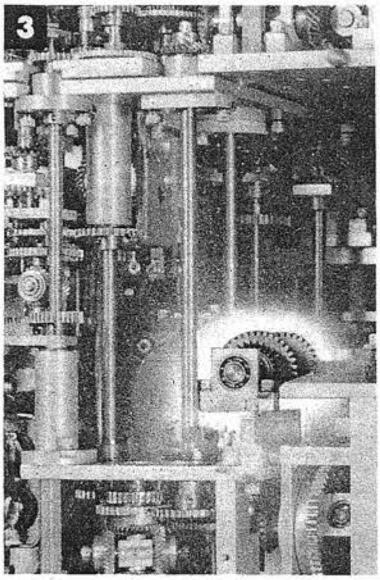




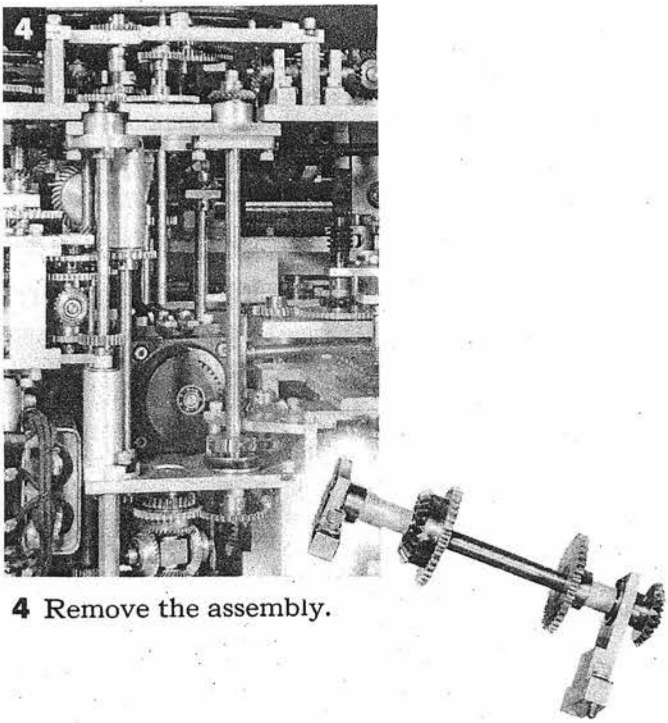
1 Remove the screws from the terminal connections of the section of the A cable not disconnected during removal of the *Sh* follow-up. Loosen the screws securing the cable clamps.



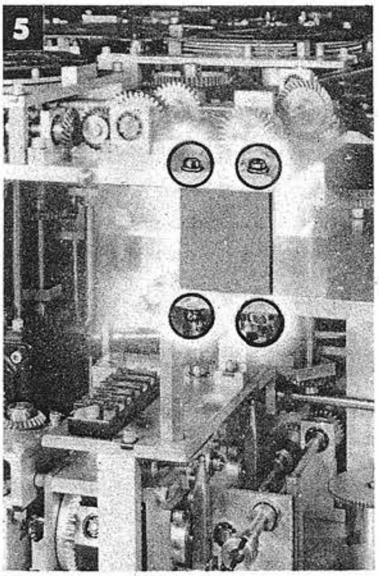
2 Free the cable back to the point where it emerges near the *jE* follow-up.



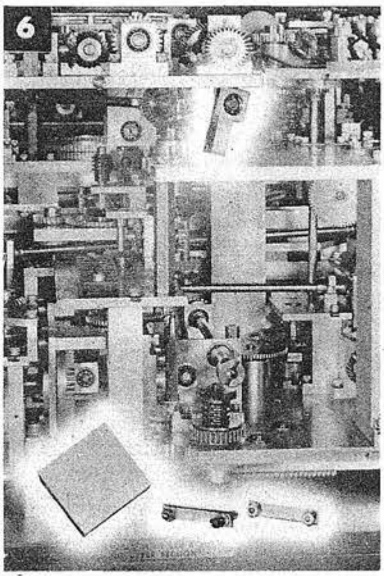
3 Remove the four screws securing the shaft assembly connecting with the *jdR* clutch.



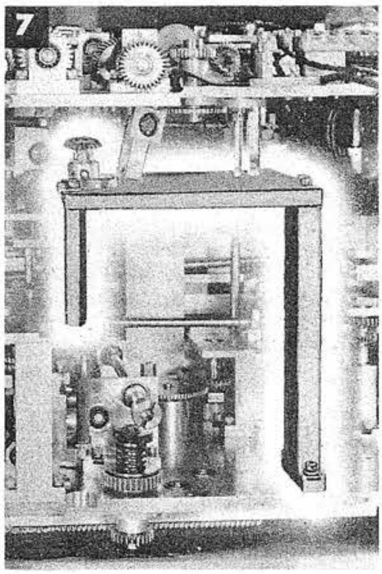
4 Remove the assembly.



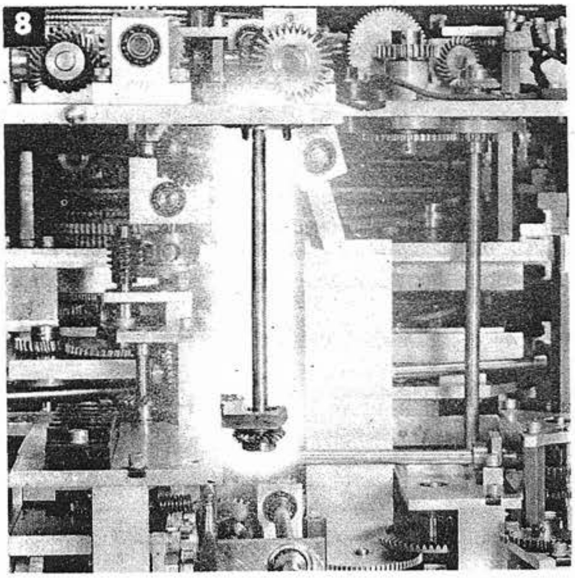
5 Remove the four screws securing the supporting plate below the top computer plate.



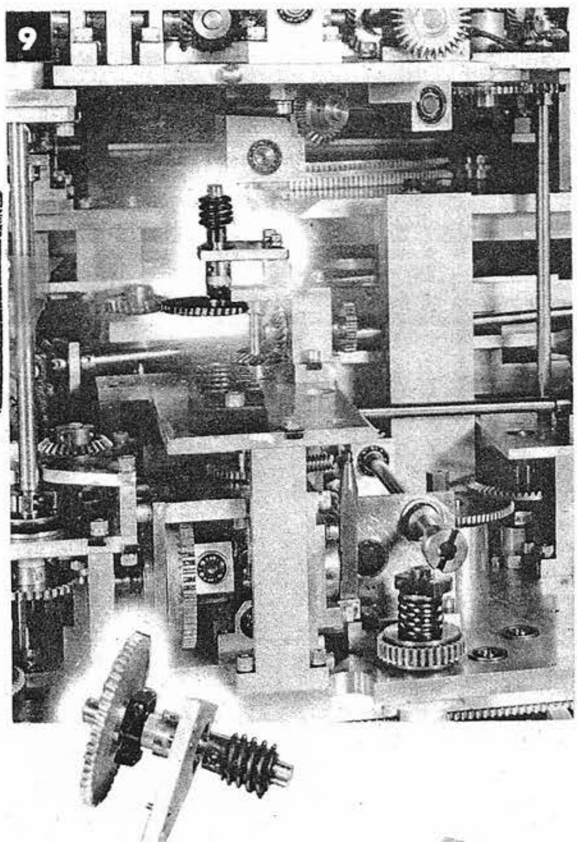
6 Remove the supporting plate.
Remove the two screws holding a worm shaft assembly to the top plate of the computer.



7 Remove all the screws securing the plate below the top computer plate. Remove the two screws securing the supporting post to the lower plate. Remove the post, the upper plate, and the hexagonal post that supports the upper plate.

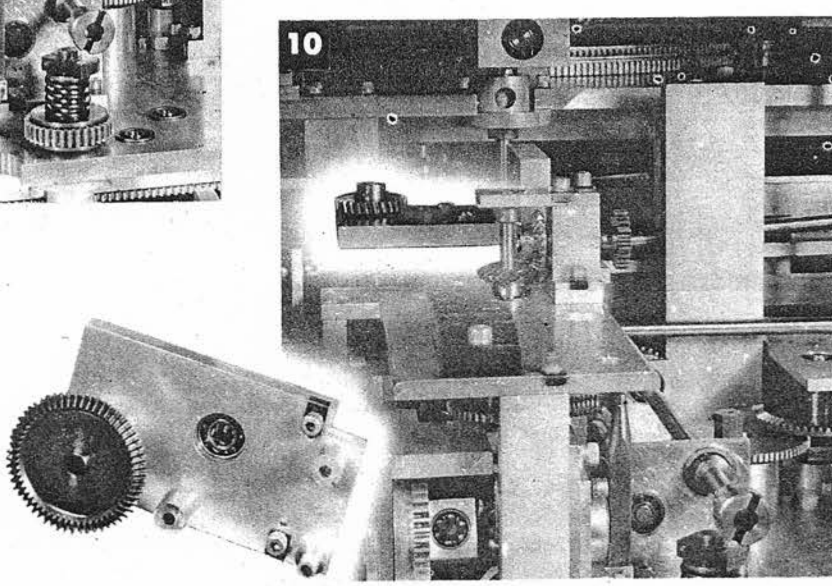


8 Remove the four screws securing the vertical shaft assembly above the inner end of the elevation component integrator. Remove the shaft assembly.



9 Remove the two screws securing the worm shaft assembly on which clamp A-258 is mounted. Remove the shaft assembly.

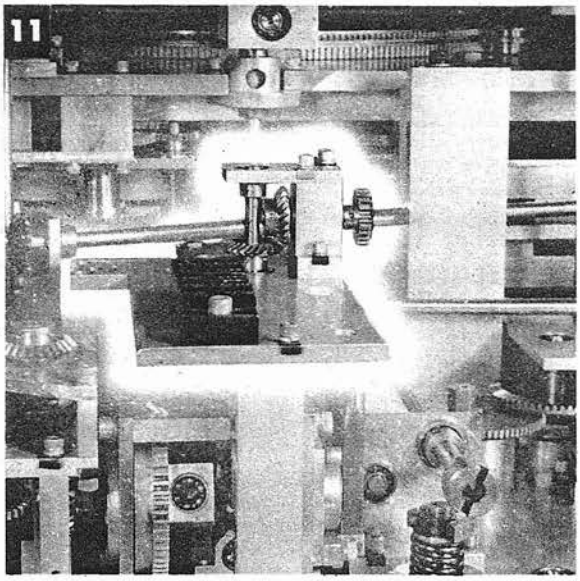
10 Remove the three screws securing the plate below the shaft assembly just removed. Remove the plate with associated gearing.



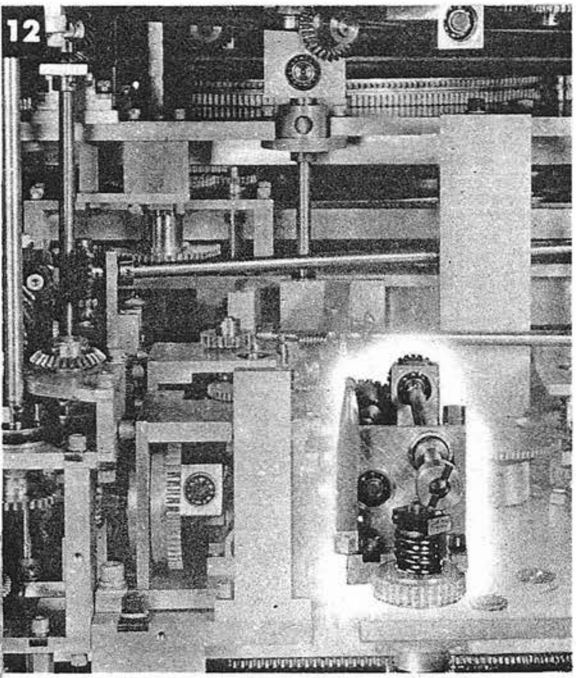
Gene Slover's US Navy Pages

Table of Contents

11 Remove the screws securing the plate on which the *Ct* terminal block is mounted, directly above the elevation component integrator. Remove the plate.



12 Remove clamp A-205, the washer and spring below it, and the hexagonal post just behind the *dH* input coupling.



13 Remove the four screws from the *dH* input shaft hangers. Remove the shaft assembly.

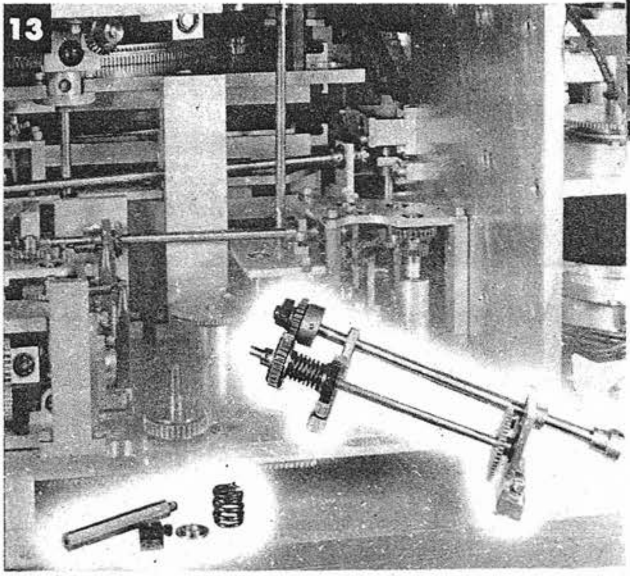
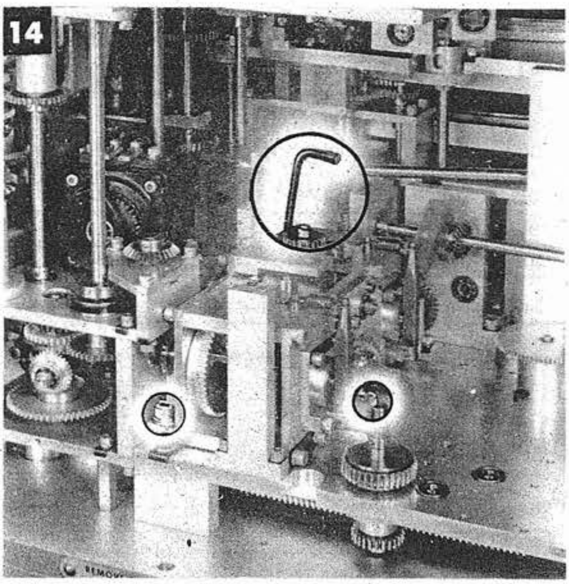
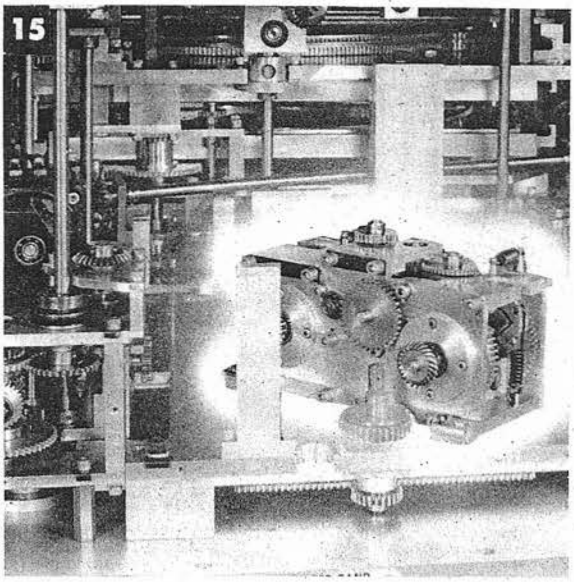


 Table of Contents

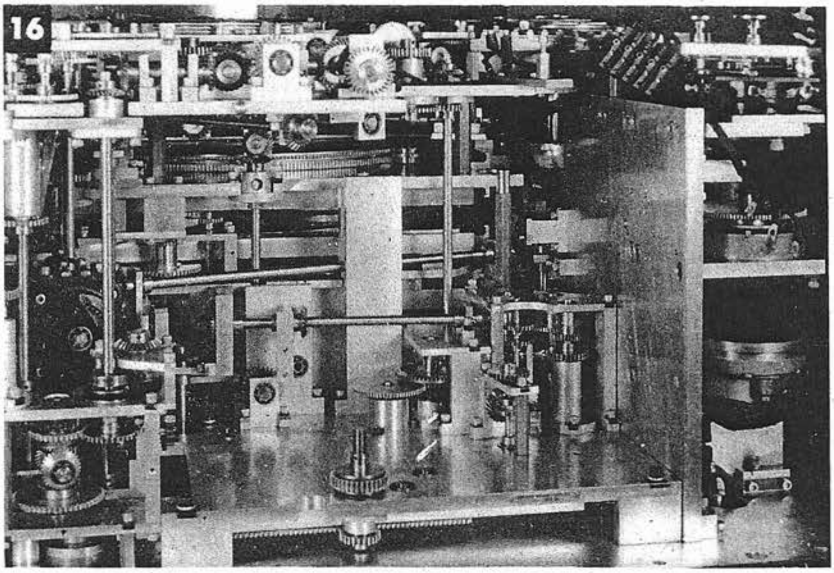


14 Back out the two screw dowels and remove the three screws securing the integrator. To reach the back screw, turn the integrator toward the front of the computer.



15 Turn the integrator to clear the gearing.

16 Remove the integrator.



To reinstall the mechanism, reverse the removal procedure.

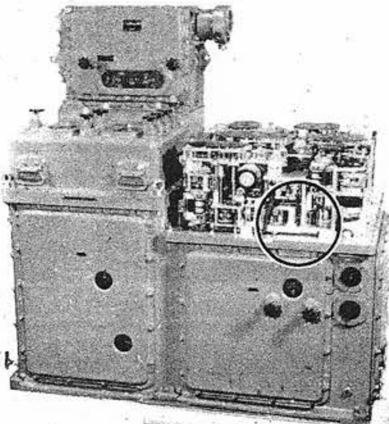
Reinstall all the units removed.

Loosen clamps A-136 and A-137.

Readjust clamp A-126.

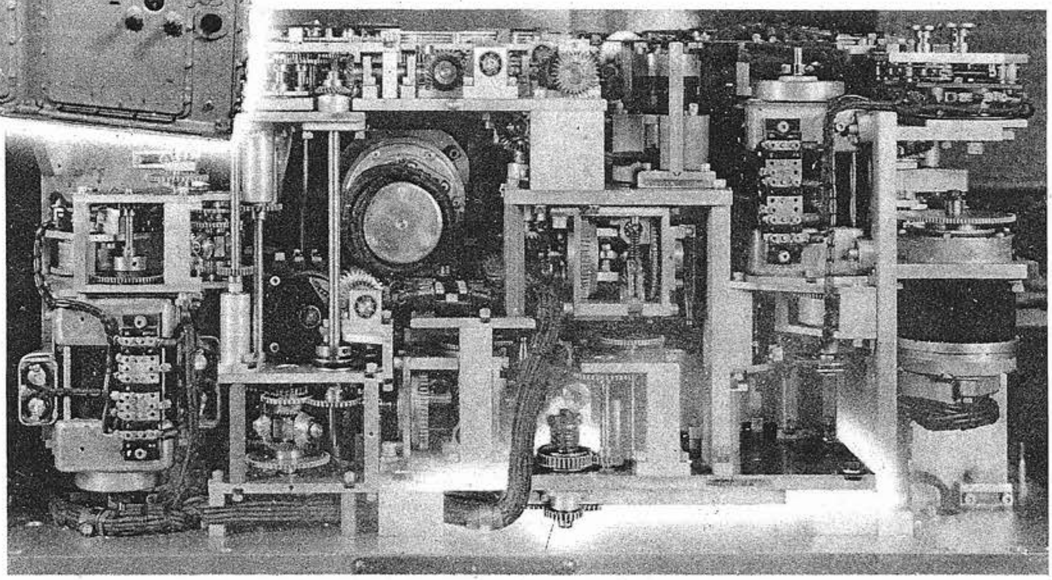
Check clamps A-163 and A-118.

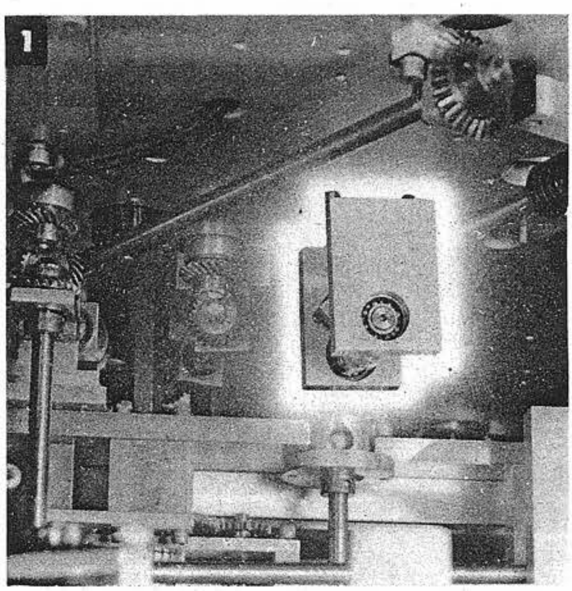
 A [illegible] -205.



VECTOR SOLVER

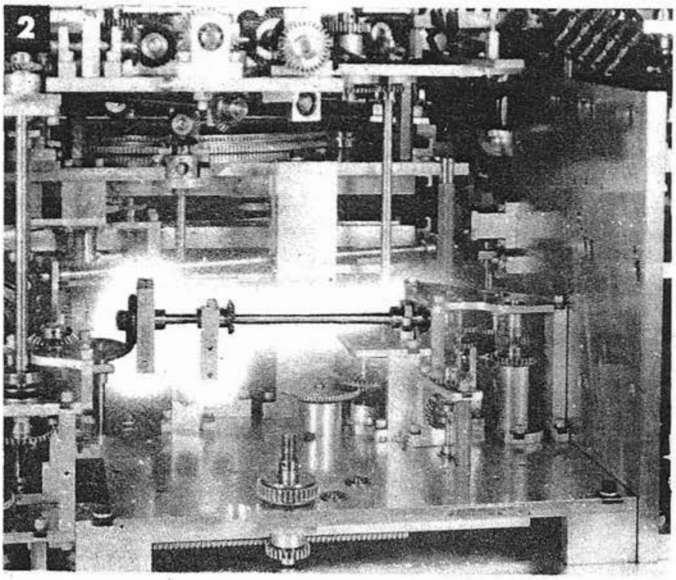
Ct Transmitter, page 611
Bearing Component Integrator, page 626
Sh Follow-up, page 593
Elevation Component Integrator, page 628

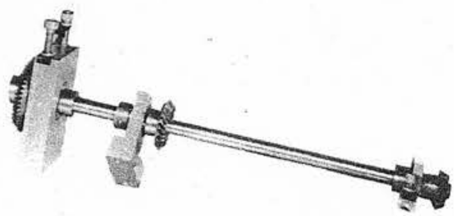




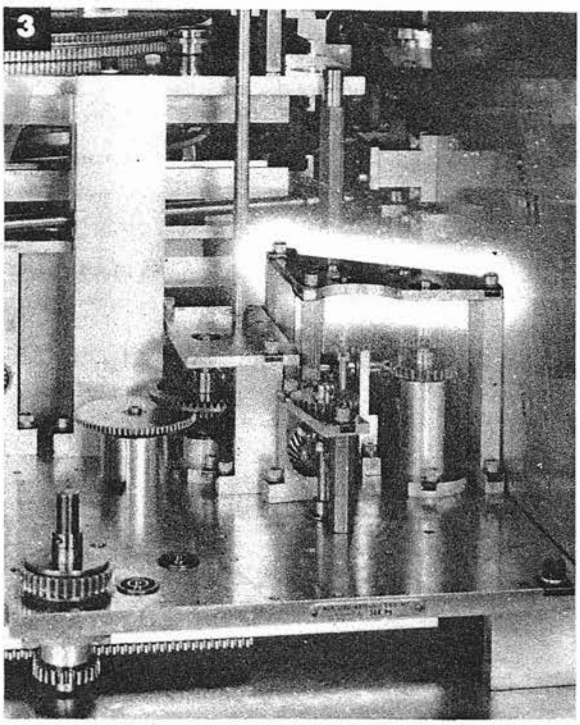
1 Loosen clamps A-136 and A-137.

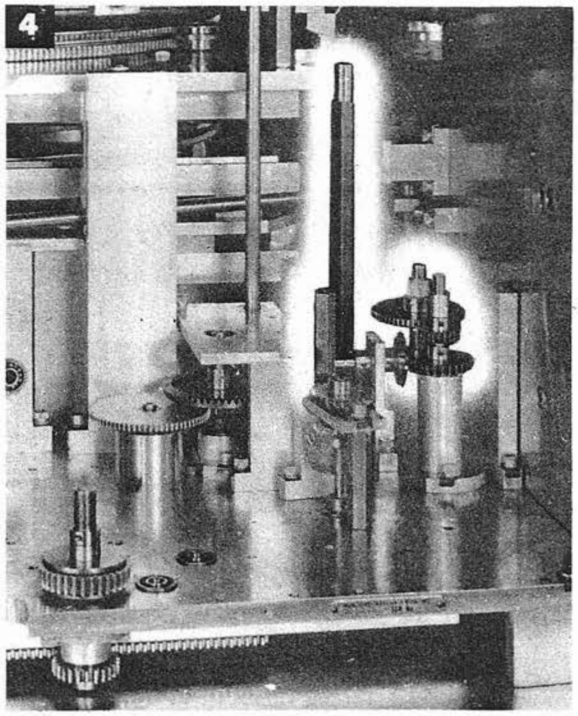
From the top plate of the computer, remove the four screws suspending the *dH* limit stop (L-4) over the vector solver.
Remove the limit stop.





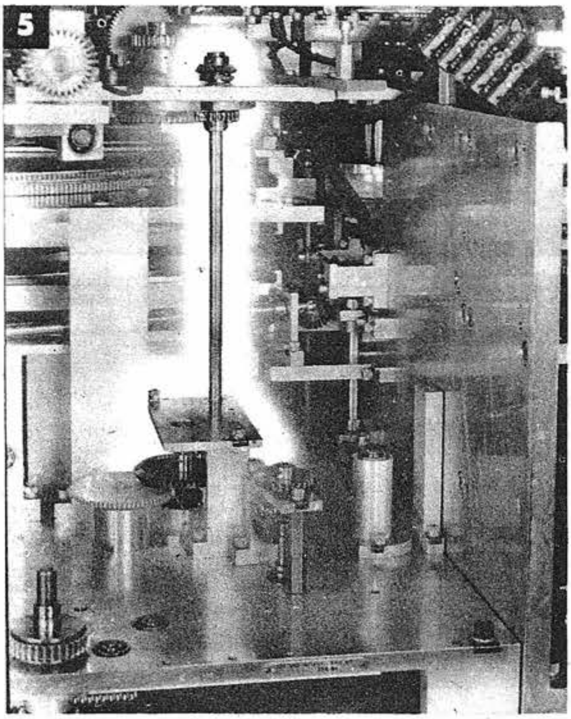
2 Remove the four screws securing the horizontal shaft assembly above the inner edge of the vector solver.
Remove the shaft assembly.
Remove the two screws securing the hanger to the small plate.

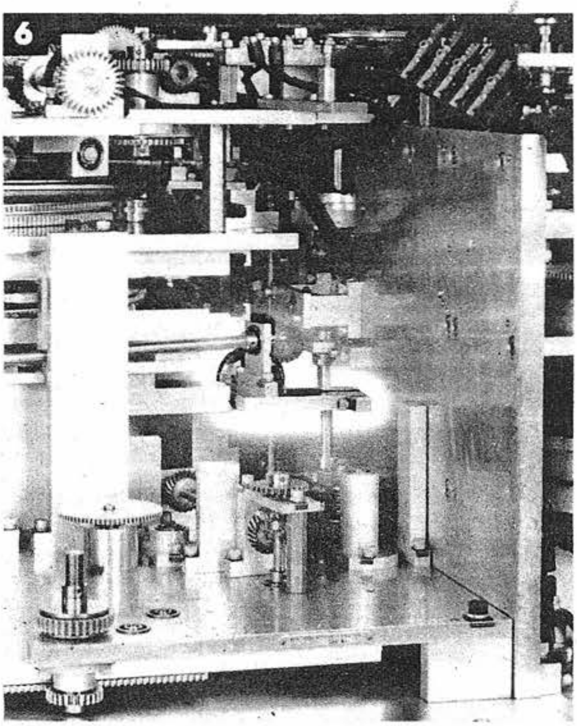




3 Remove the three screws securing the upper plate on the *Sh* input gearing.
Remove the plate.

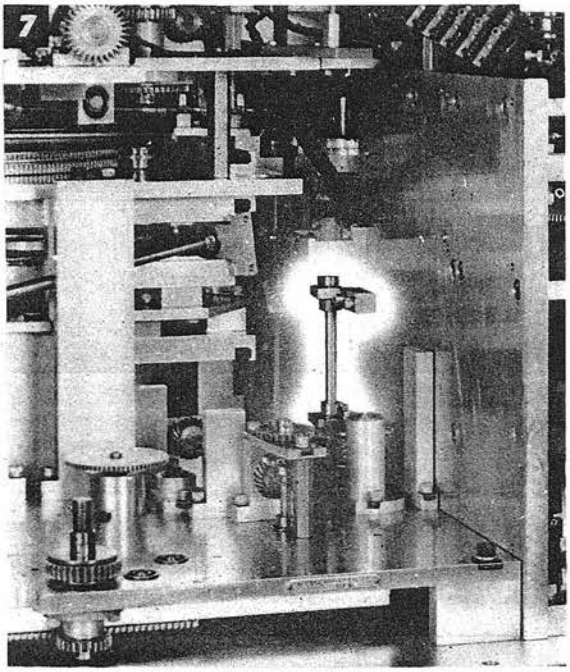
4 Lift out the two shaft assemblies below the removed plate.
Remove the two hexagonal posts.



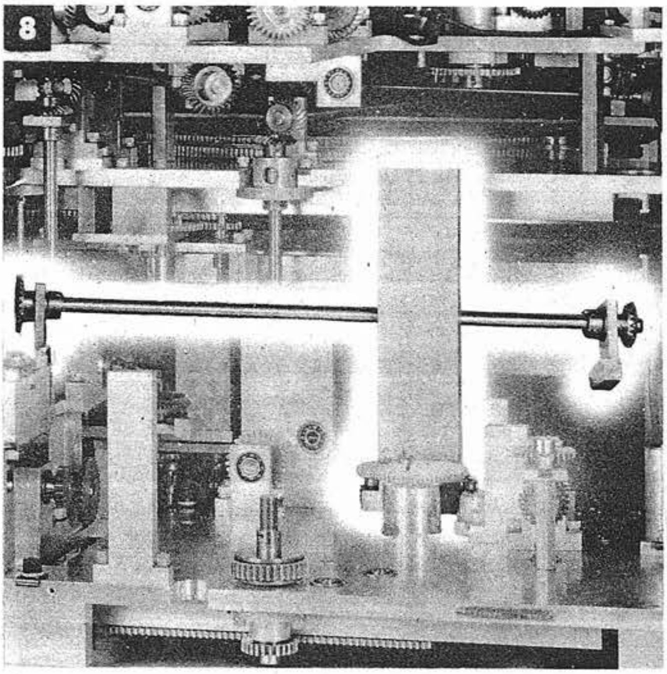


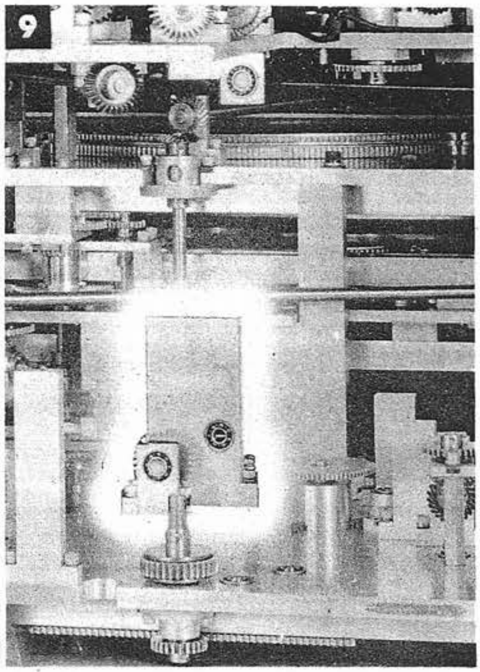
5 Remove the two screws securing the plate directly above clamp A-137.
Remove the two screws securing the adapter for the shaft that rises from this plate to the top plate of the computer.
Remove the small plate and the shaft assemblies.

6 Remove the screws securing the horizontal shaft assembly mounted on a bracket attached to the front plate of the computer. Lay the shaft back, out of the way.
Remove the two screws securing the bracket.
Remove the bracket.



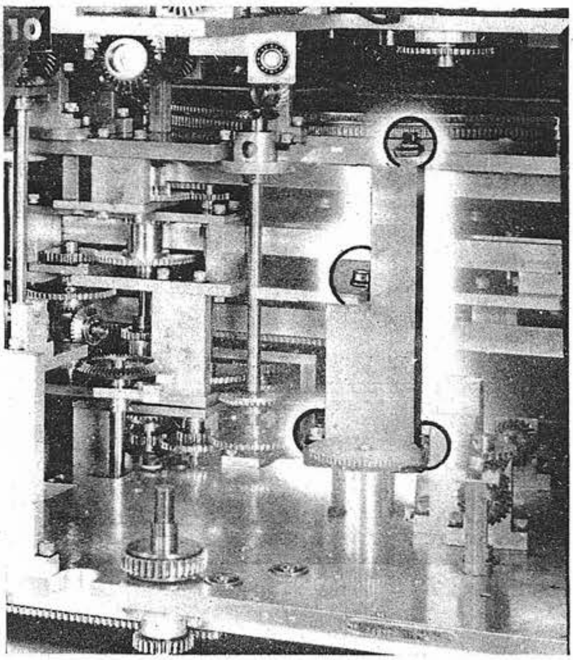
7 Remove the four screws securing the short vertical shaft assembly toward the back of the front plate. Remove the assembly.

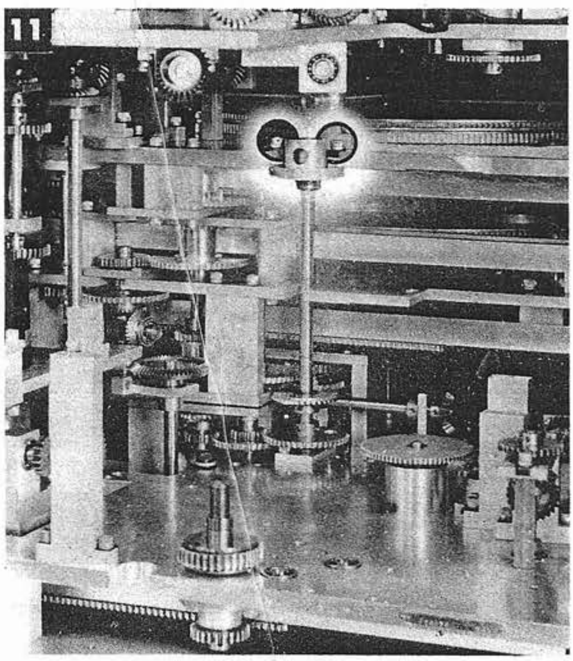




8 Remove the two screws securing the large post toward the rear of the vector solver. Remove the post.
Remove the loose shaft assembly behind this post.

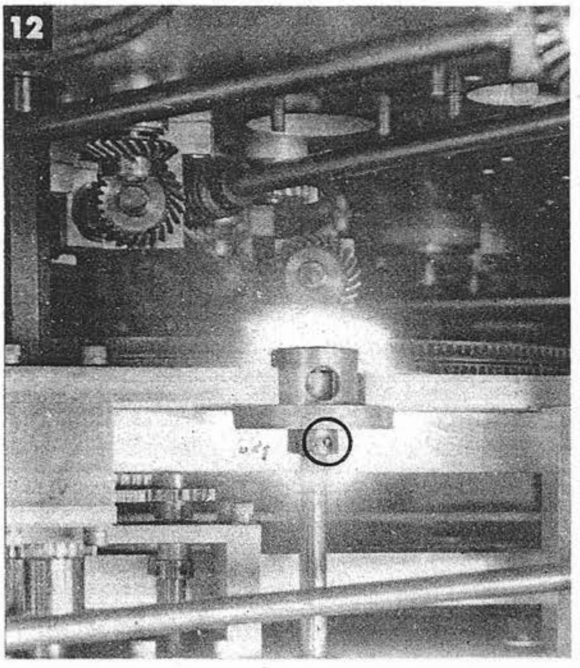
9 Remove the screws securing the rear hangers of the *dH* input shafts.
Remove the two hangers and the short shaft between them.



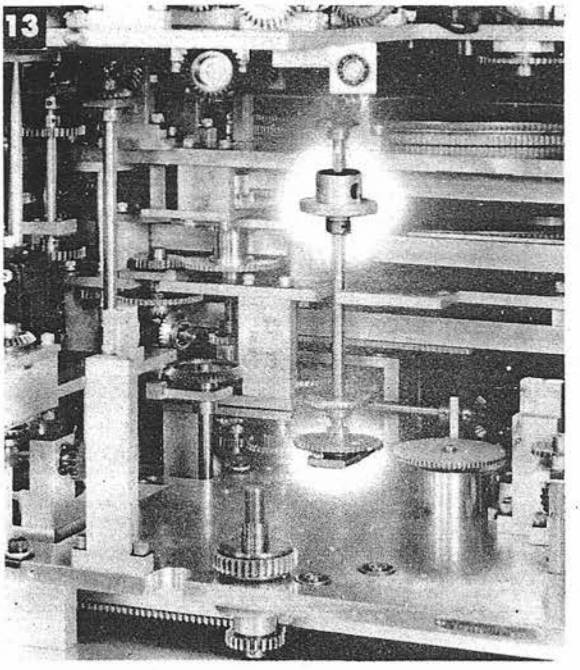


10 Remove the four screws securing the L-shaped supporting post for the component solvers. Remove the post.

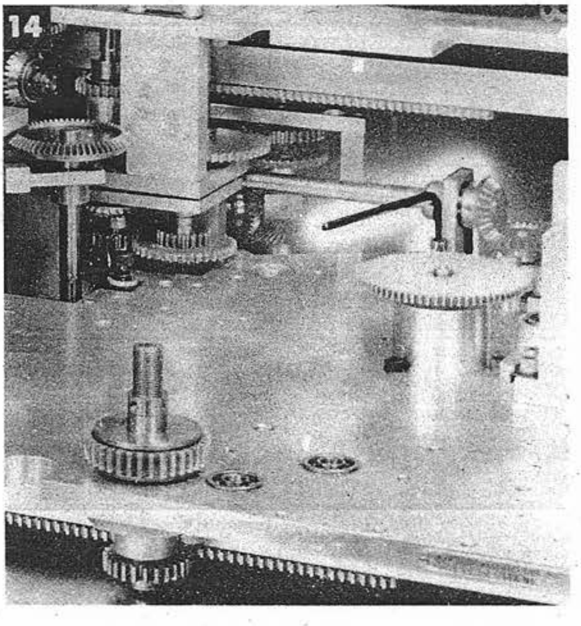
11 Remove the two screws securing the adapter to the plate of the height computer.



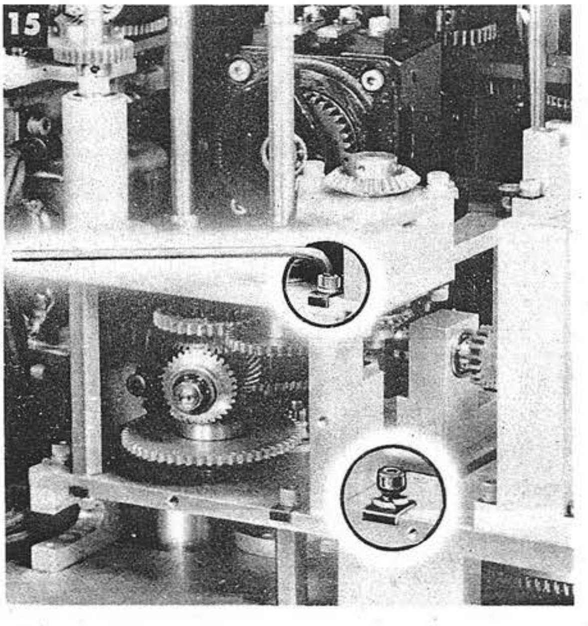
12 Unpin the collar below the adapter.



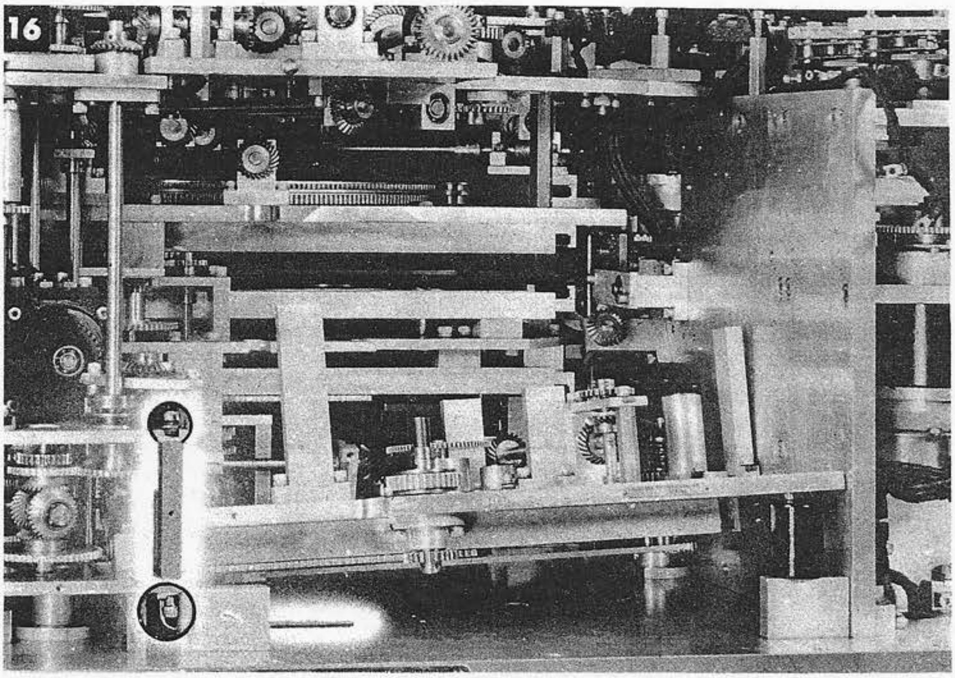
13 Slide the collar and the adapter down. Through the access holes in the gear, remove the two screws securing the hanger at the base of the shaft.
Remove the shaft assembly.



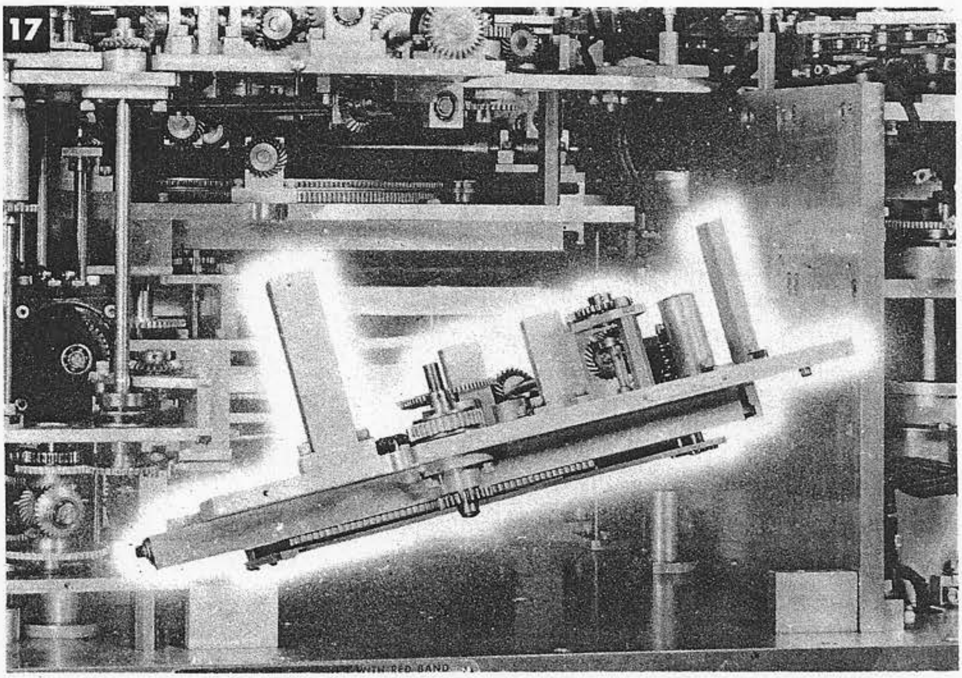
14 Remove the two screws securing the hanger to the vector solver plate. It is not necessary to remove this shaft assembly.



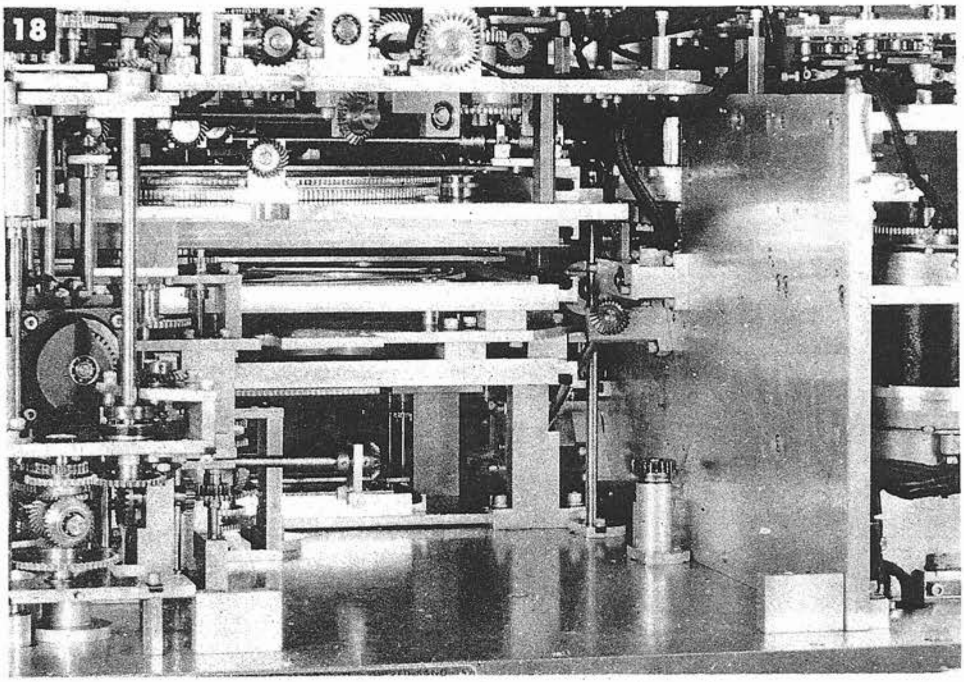
15 Remove the screw securing the post near the *jdR* clutch.
Remove all the screws securing the vector solver mounting plate to the computer.



16 Lift the vector solver slightly to gain access to the lower two screws securing the supporting post.
Remove the screws and the post.



17 Tilt the front edge of the vector solver up, to clear an adapter and shaft of the time line.



18 Remove the vector solver.

To reinstall the mechanism, reverse the removal procedure.

Reinstall all the mechanisms removed.

Loosen clamp A-126.

Readjust clamps A-525 and A-192.

Check clamps A-119 and A-121.

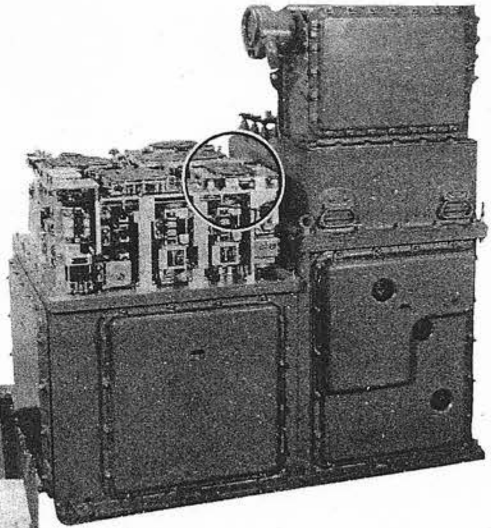
Readjust clamp A-126.

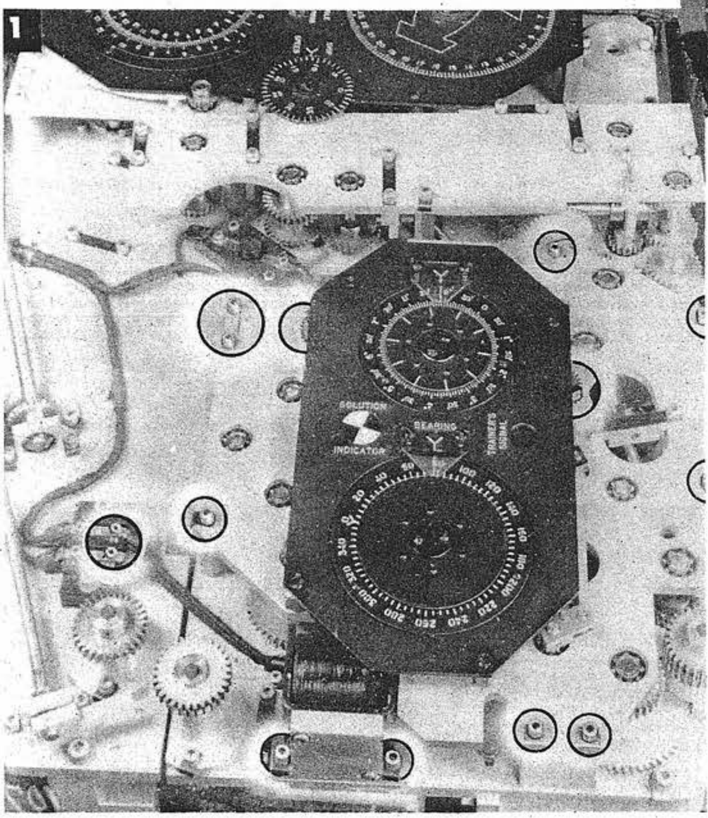
Check clamps A-163 and A-118.

Readjust clamps A-115, A-117, A-136, A-137, and A-258.

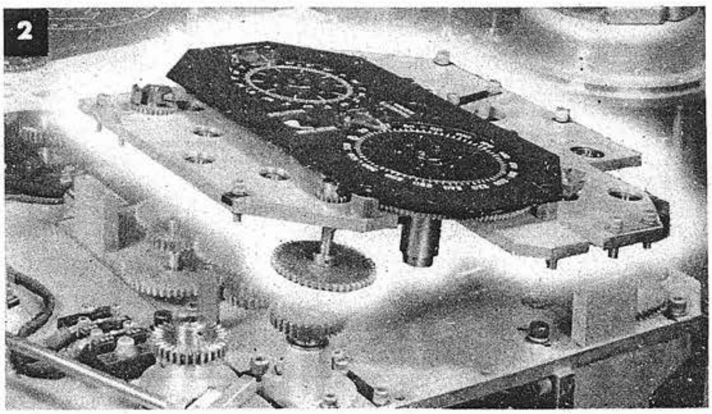
Run tests.

BEARING GEARING AND DIAL ASSEMBLY

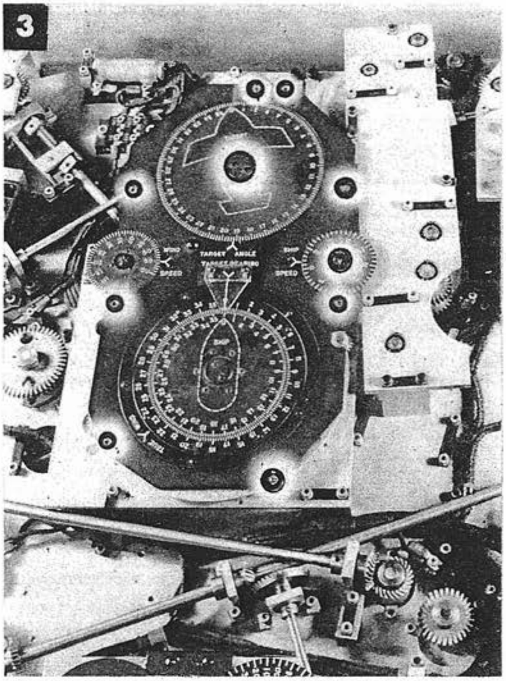




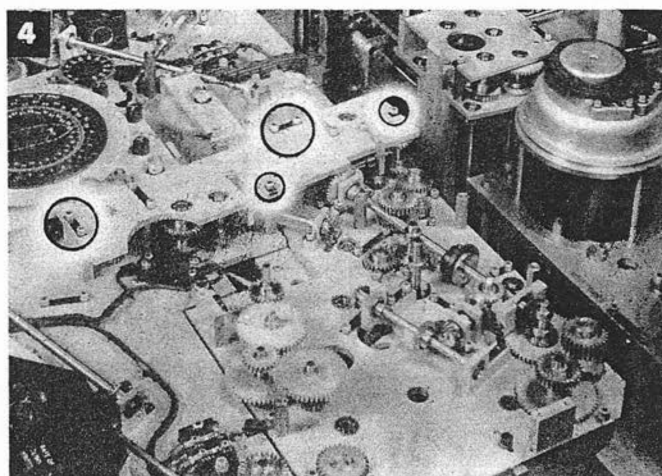
1 Remove the eight screws securing the upper plate.
Loosen clamps A-194 and A-197.
Remove the screws connecting cable leads TS and TSS to the terminal block.
Remove the two screws securing the solenoid hanger to the plate. Remove the solenoid.



2 Remove the plate with shafts attached.
Remove the gears on which A-197 and A-194 are mounted.
Remove the spacer below A-194.



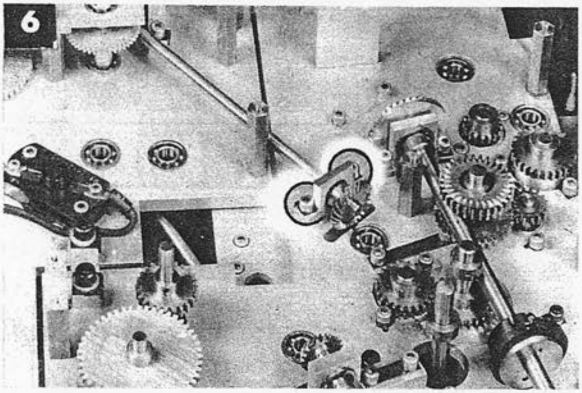
3 Remove the eight screws securing the mask.
Remove the mask.
Remove the dial clamps from the target dial and the ship speed dial.
Remove the two dials.

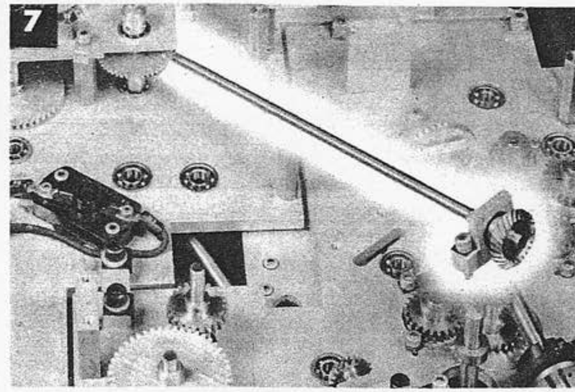


4 Remove the six screws securing the plate located next to the bearing gearing.

5 Lift out the plate.

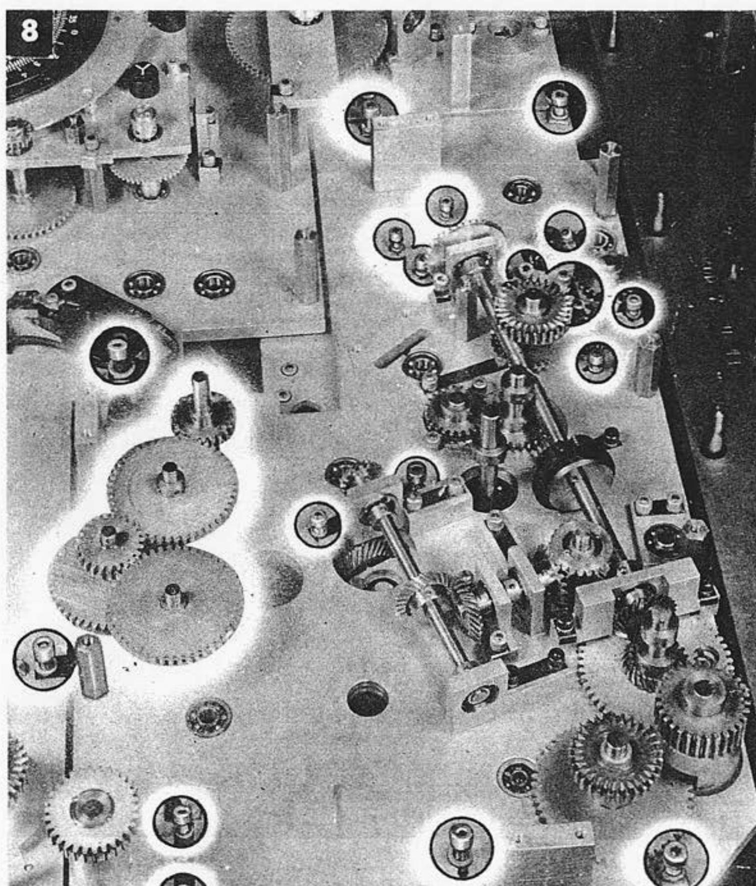
641



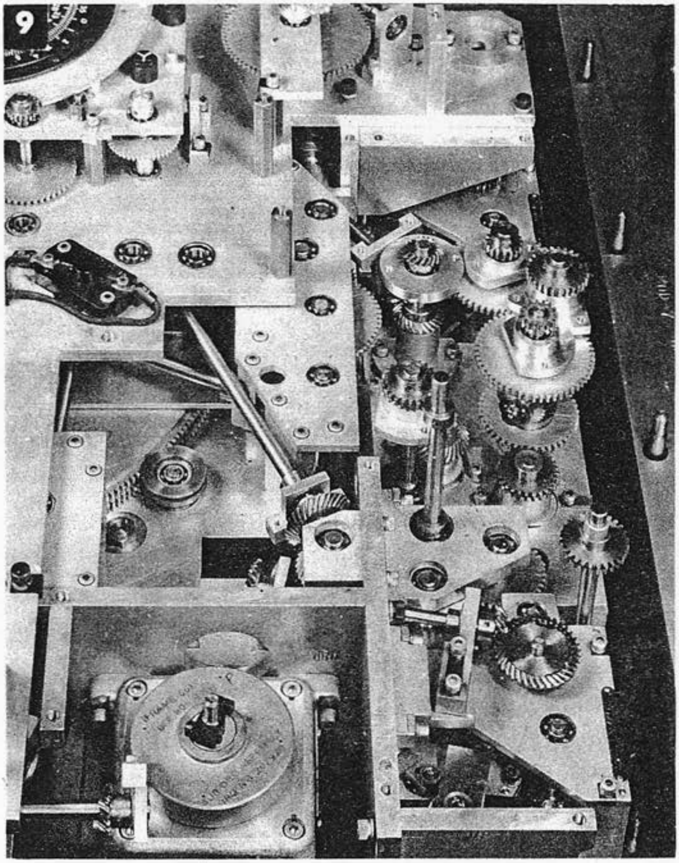


6 Remove the two screws securing the shaft assembly that connects with the *A* dial.

7 Remove the shaft assembly.



642

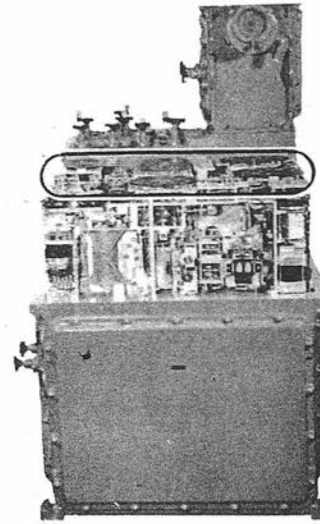


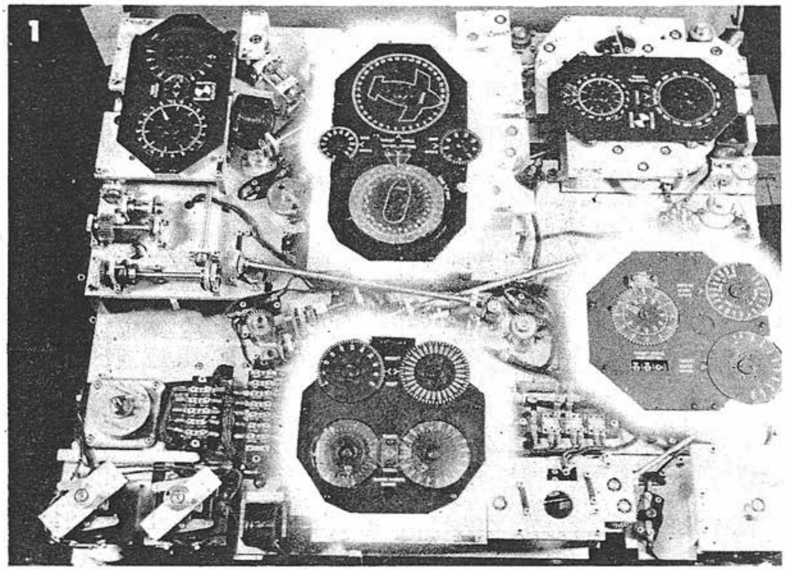
643

9 Remove the plate.

TOP PLATE OF CONTROL UNIT

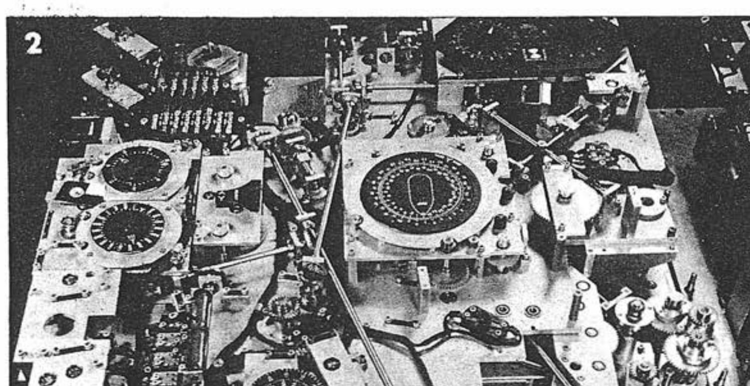
Bearing Dials and Gearing, page 640
Ct Transmitter, page 611



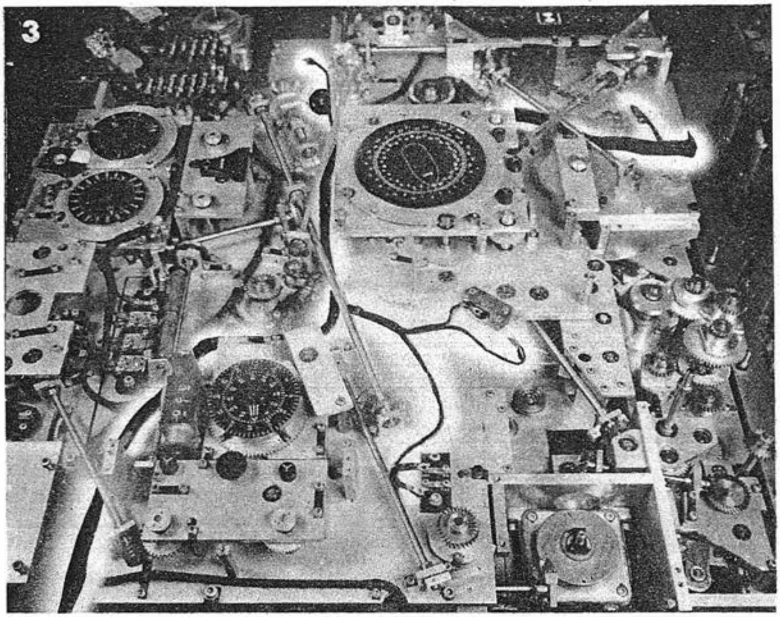


1 Remove the dial clamps on the *So, Sw, dH, dR, H,* and *A* dials.
Remove the dials.

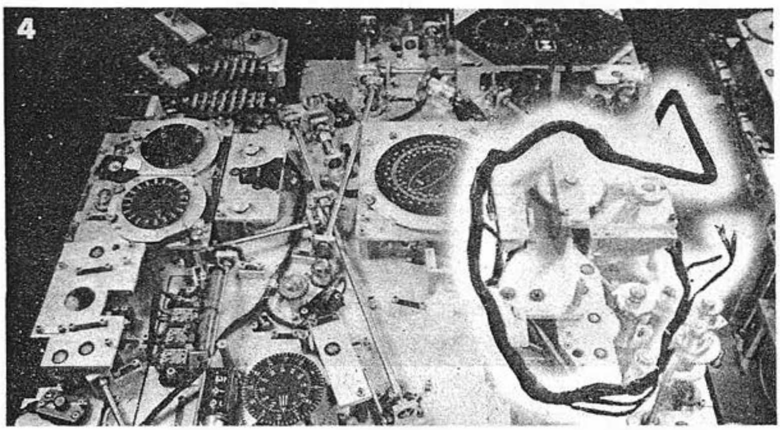
2 Remove the screws securing the masks around the time, range, and target dial groups. Remove the masks.



There are two sections of cable, A and B, connected to terminals on the top plate. Remove all the terminal connection screws. Remove the cable clamps. Free the cable from the clamps, shafts, and other obstructions. Lay the cable aside, out of the way.

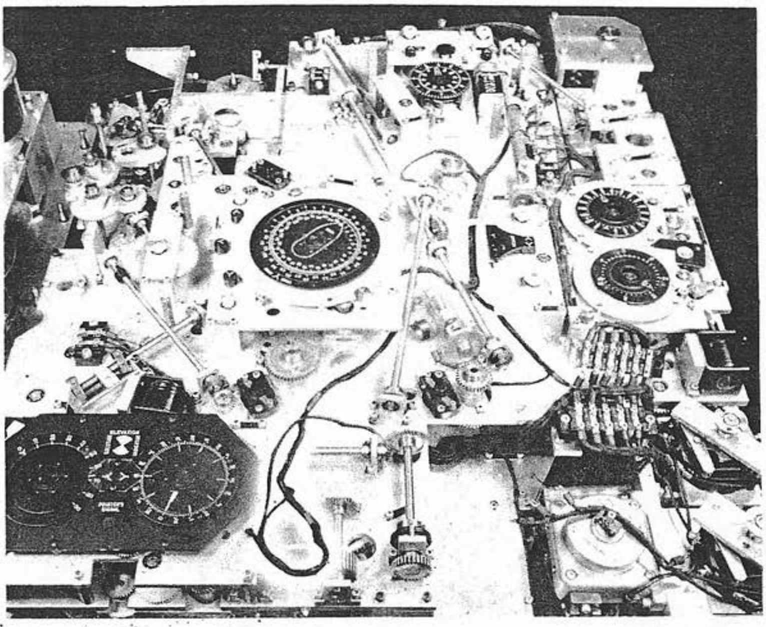


3 Cable A

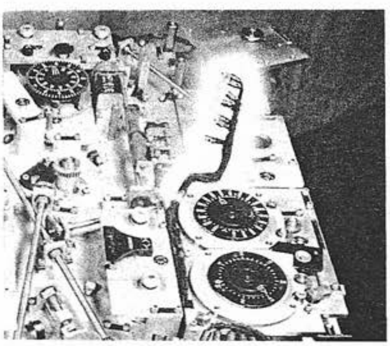


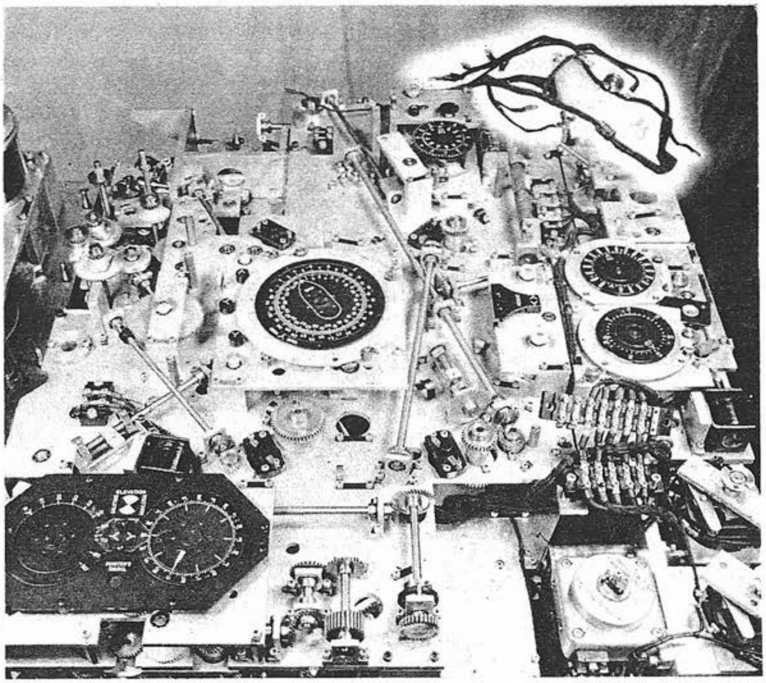
6 45

5 Cable B

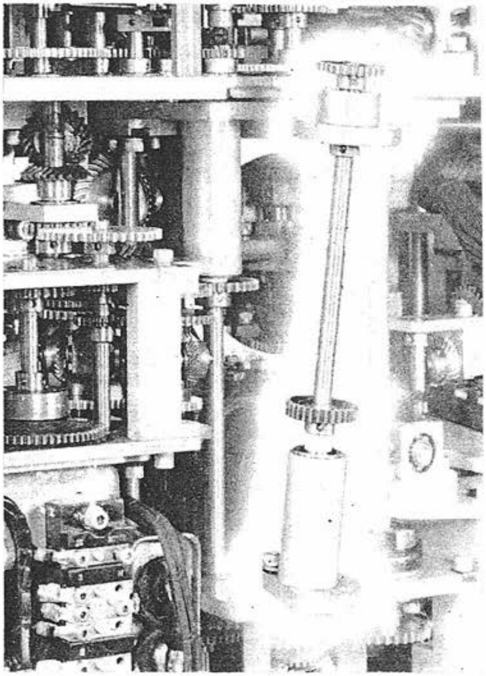


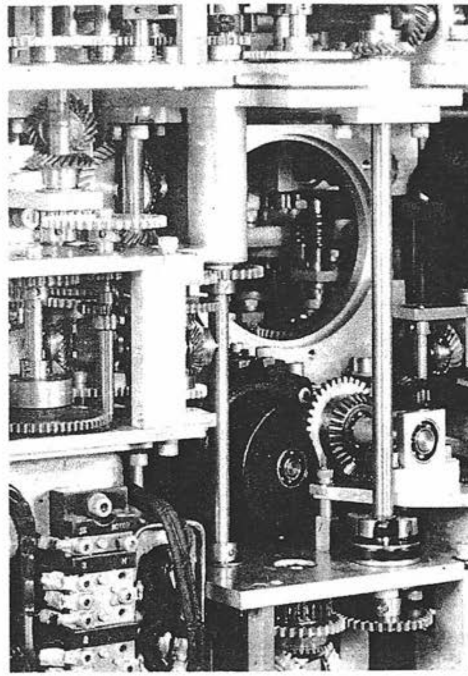
NOTE:
There are cable clamps on the under side of the top plate near the *Ct* transmitter.





646



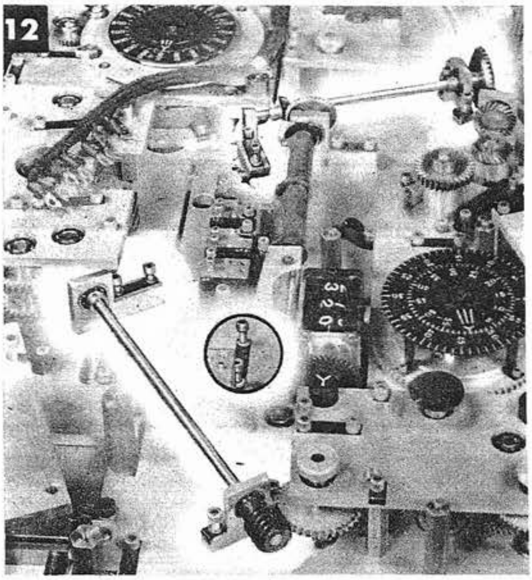


8 Remove the four screws securing the vertical shaft assembly next to the *jE* follow-up.

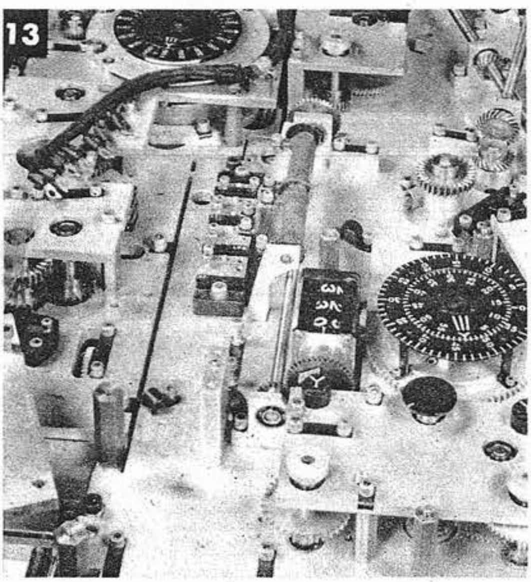
9 Remove the assembly.

10 Remove the pointer's signal solenoid. See page 620
Remove the mask around the elevation dials.

11 Remove three screws securing the top plate.

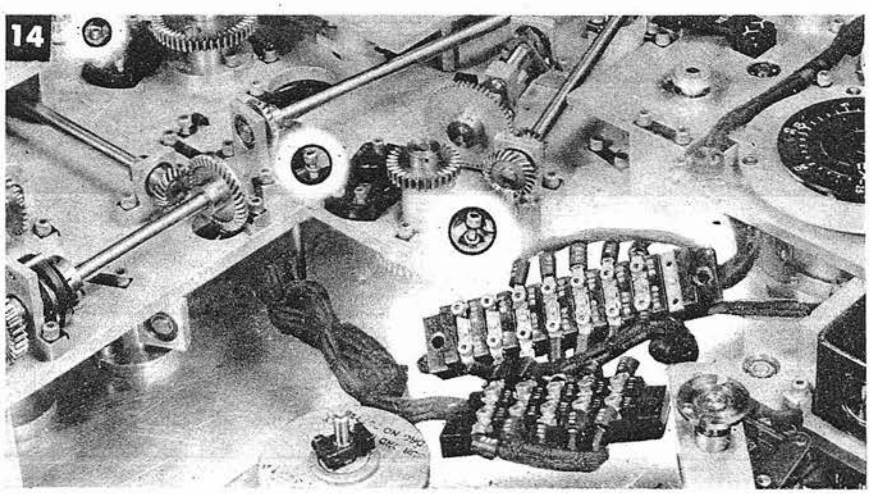


12 Remove the four screws securing the two shaft assemblies that cross over from the top plate to the plate near the range receiver.
Loosen the two screws in front of the *Sh* counter.



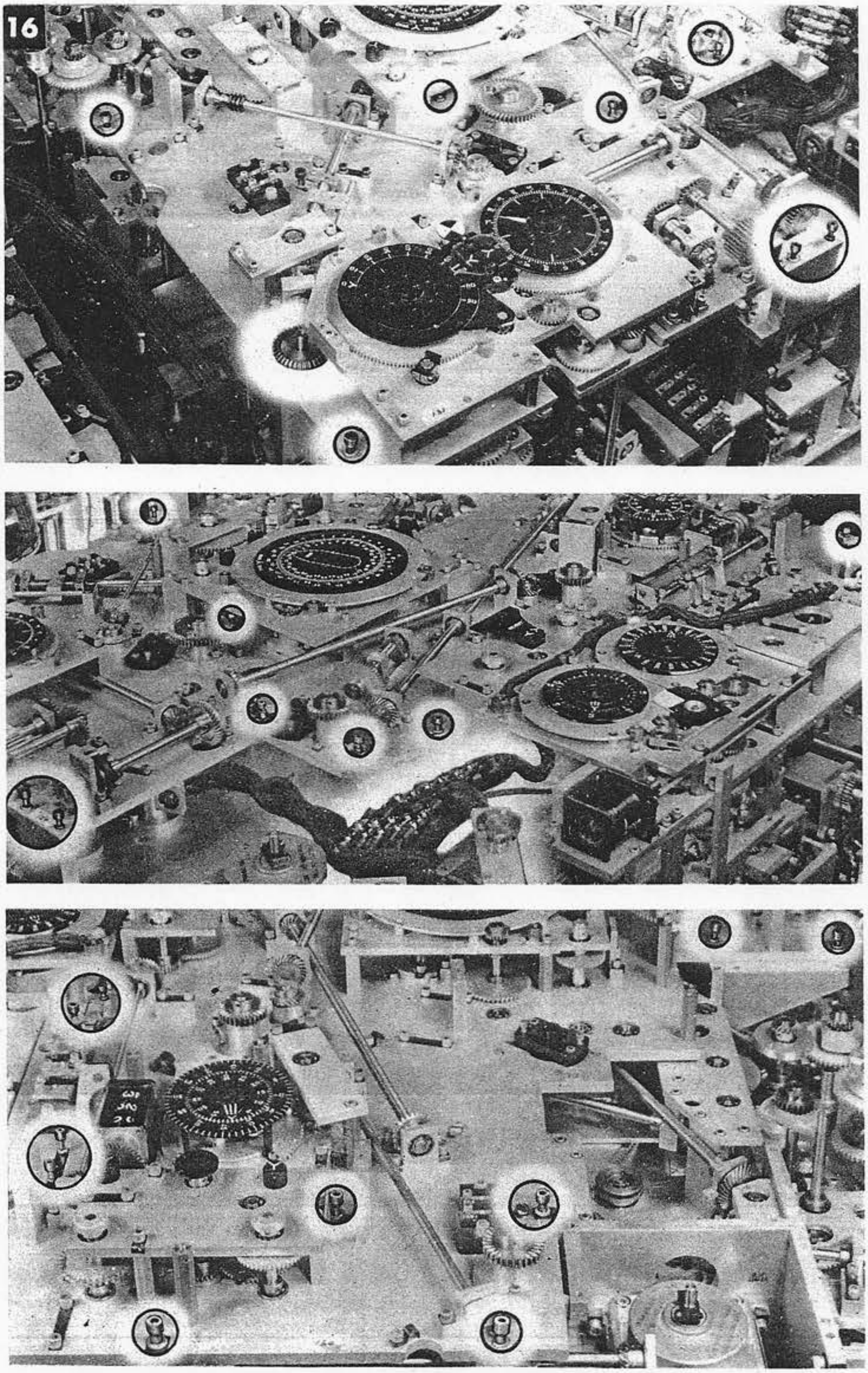
13 Remove the two shaft assemblies.

14 Remove the four screws securing the two terminal blocks next to the range receiver. Push the blocks aside.
Remove the six screws securing adapters to the top plate on the corner near the terminal blocks.



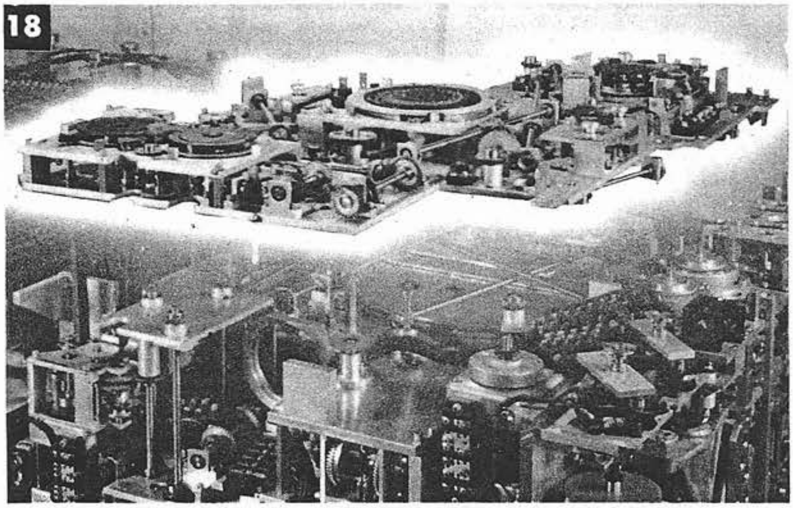
15 Remove the two screws securing the adapter for the shaft assembly near the elevation dials. Remove the shaft assembly.

16 Remove the screws securing the top plate.

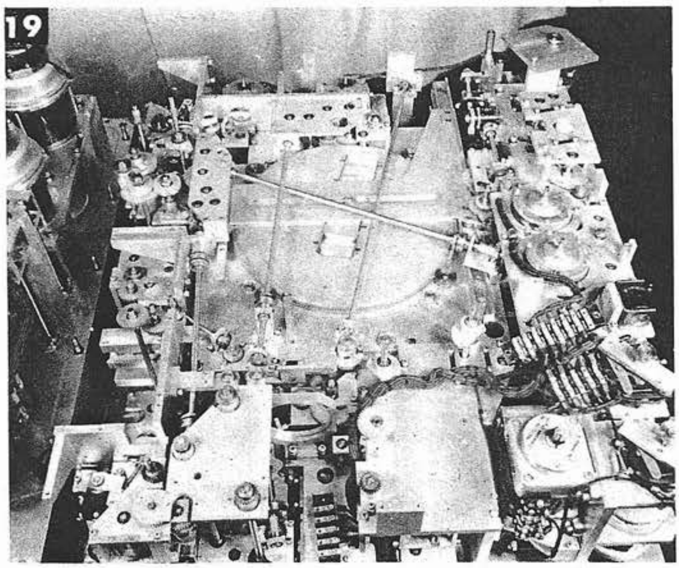


17 Remove the range receiver gearing unit. See page 621.

18 Back out the three screw dowels. Lift the plate straight up to free the gear meshes.



19 Remove the plate.



To reinstall the top plate, reverse the removal procedure.

Reinstall the bearing gearing and dial assembly, the range receiver, and the *Ct* transmitter.

Tighten clamp A-190.

Disconnect the power leads from all follow-ups in the control unit.

Loosen the following adjustments.

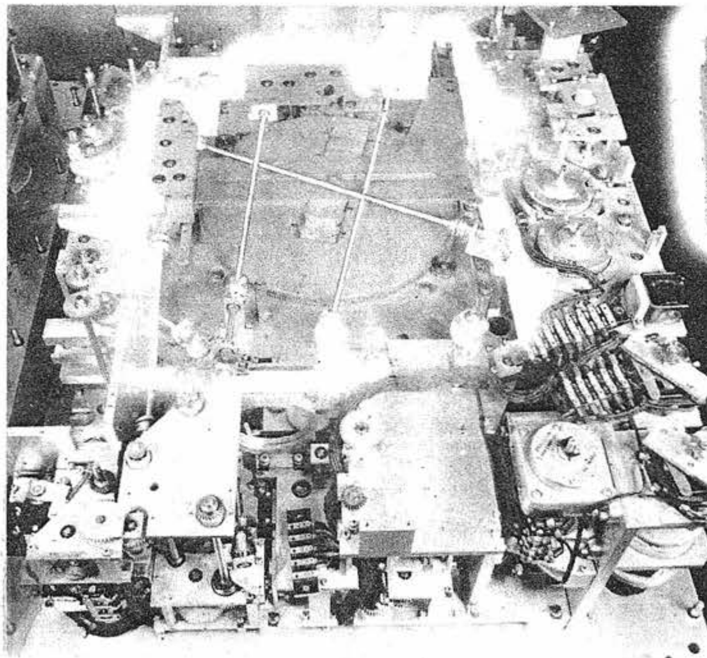
A-527	A-118	A-521
A-197	A-121	A-240
A-531	A-204	A-164
A-194	A-529	A-124
A-127	A-201	A-158
A-193	A-533	A-522
A-532	A-136	A-523
A-192	A-137	A-138
A-528	A-115	A-116
A-524	A-117	A-122
A-525	A-222	A-200
A-119	A-223	A-258
A-189	A-205	A-105
A-123	A-206	A-157
A-126	A-187	A-129
A-128	A-195	A-199
A-125	A-196	A-70
A-163	A-520	A-179

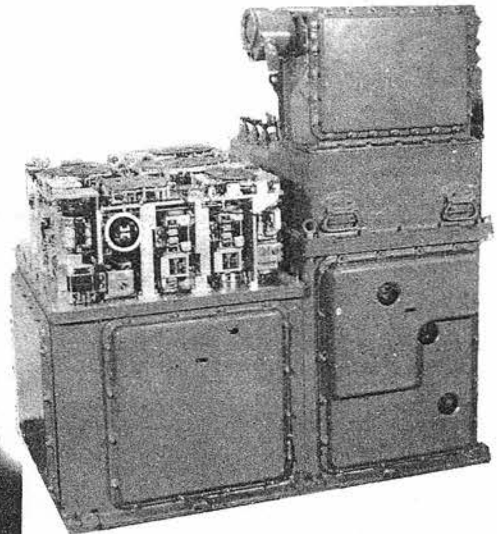
Readjust the clamps in the order listed above. Refer to *Factory Adjustment Procedure,* page 815.

Run all tests.

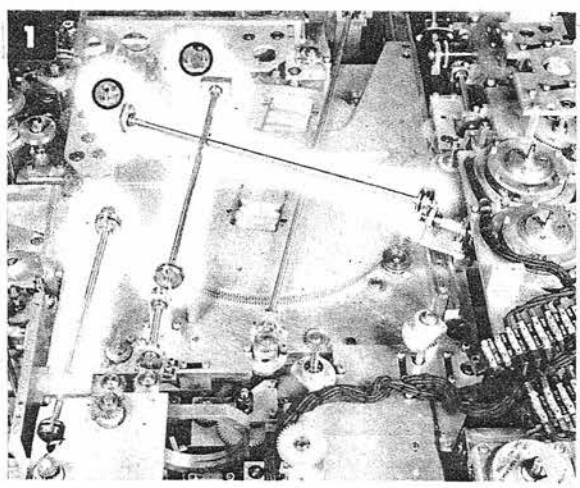
HEIGHT COMPUTER, TARGET COMPONENT SOLVER

Top Plate of the Control Unit, page 644

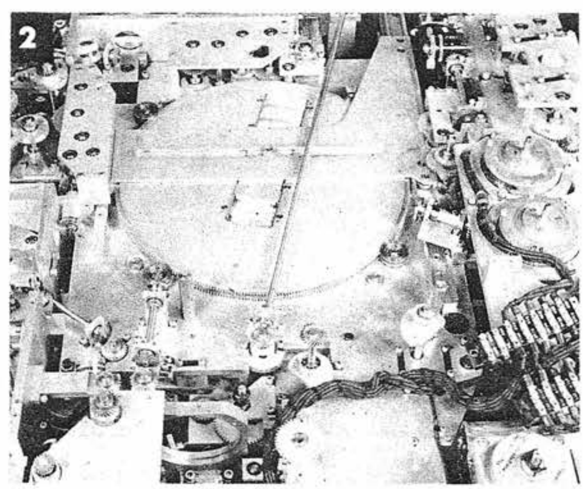




NOTE:
The height computer may be worked on without removal from the instrument, after removal of the top plate and overlying shafts.

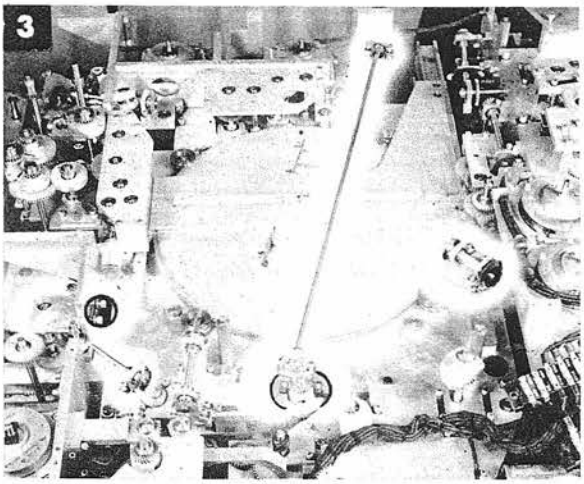


1 Remove the two screws from each of the two crossing shaft assemblies. Remove the locking spring from the coupling end of each assembly. Remove the assemblies.
Remove the locking springs from the couplings at each end of the third shaft.

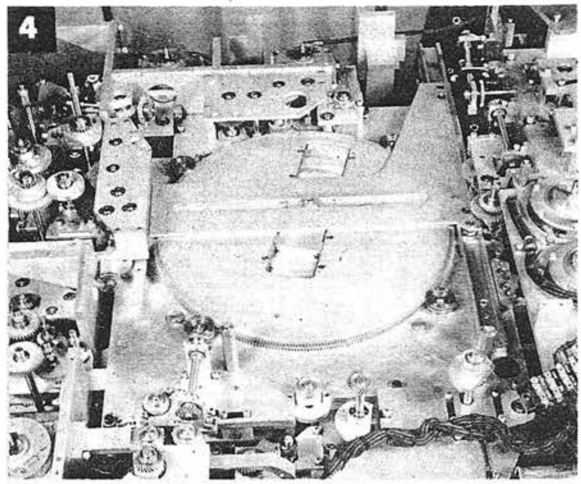


2 Slide the coupling shaft through the gearing, out of the way.

Gene Slover's US Navy Pages | Table of Contents

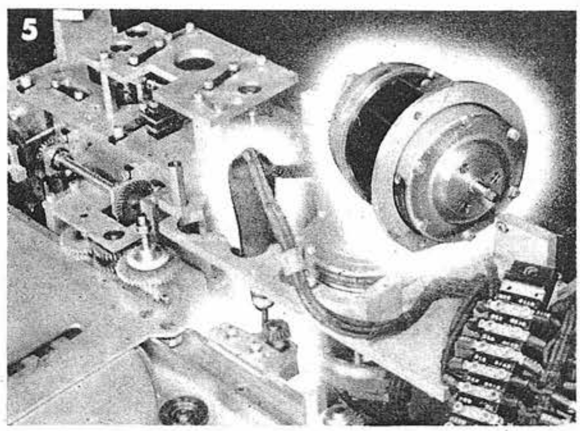


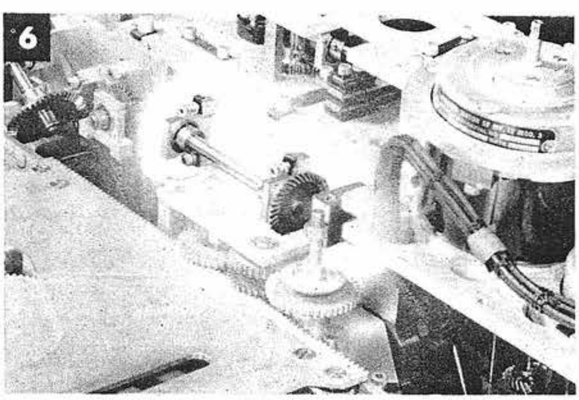
3 Remove the screws securing the three shaft assemblies indicated.



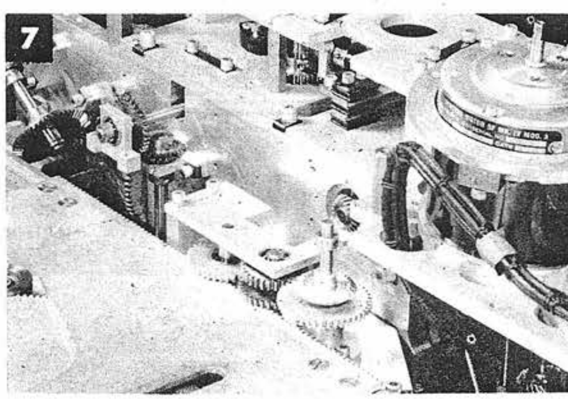
4 Remove the assemblies.

5 Remove the three screws securing the fine synchro of the range receiver. Lift the synchro out, but do not remove it.
Remove the six screws securing the vertical shaft assembly beneath the synchro bracket. This shaft assembly is attached to the edge of the height computer plate. Remove the shaft assembly. Replace the synchro.

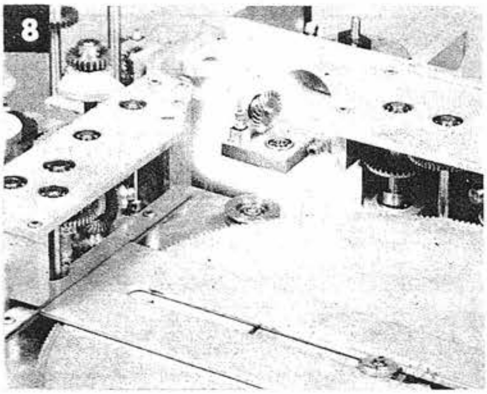




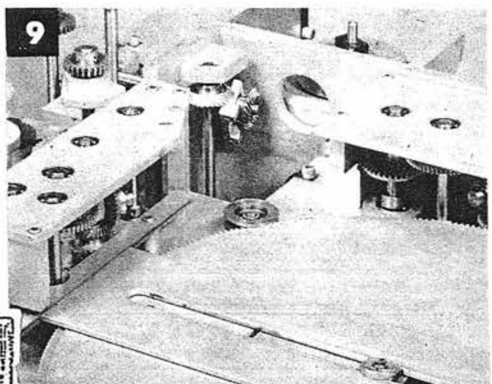
6 Remove the four screws securing the short horizontal shaft assembly near the synchros.



7 Remove the shaft assembly.

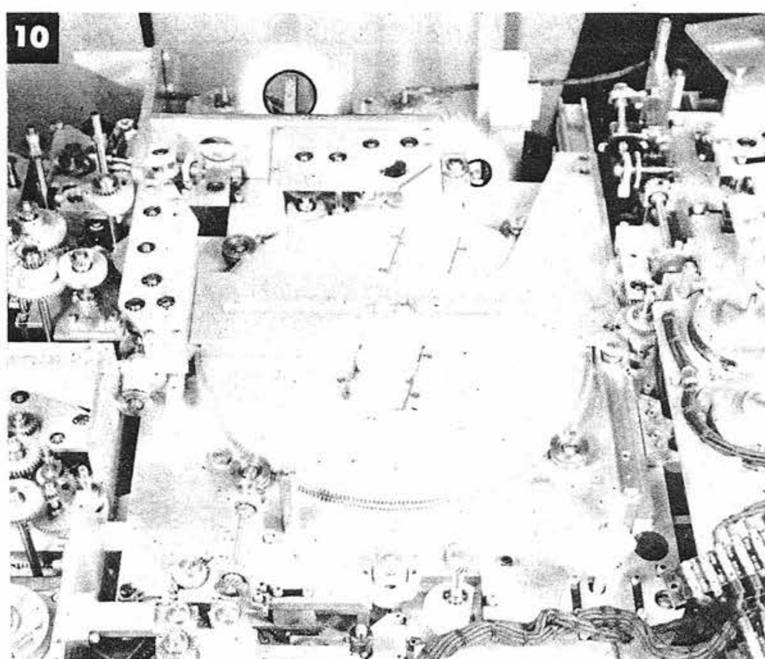


8 Remove the two screws from the hanger for a short shaft assembly near the *dRh* follow-up. Remove the two screws securing the bracket to which this hanger was attached.

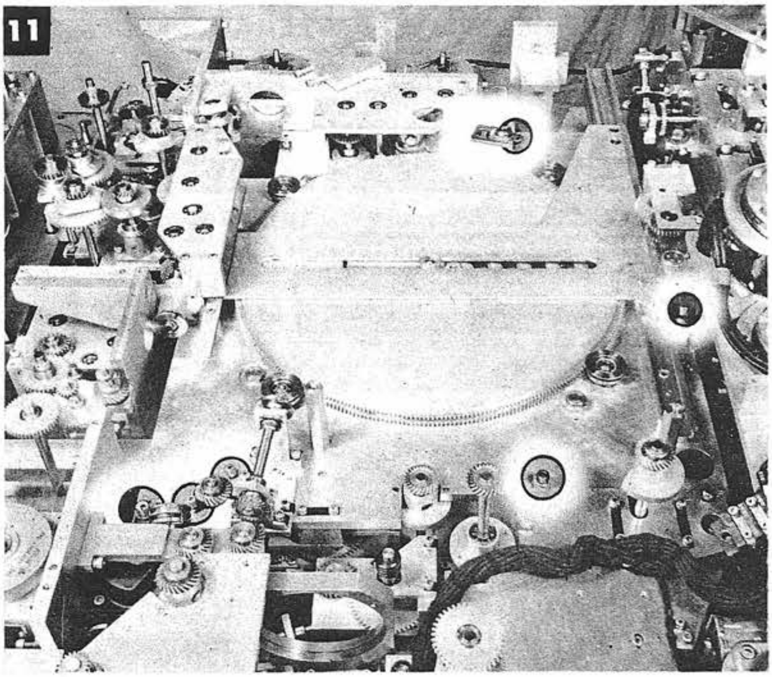


9 Remove the bracket. Push the assembly out of the way.

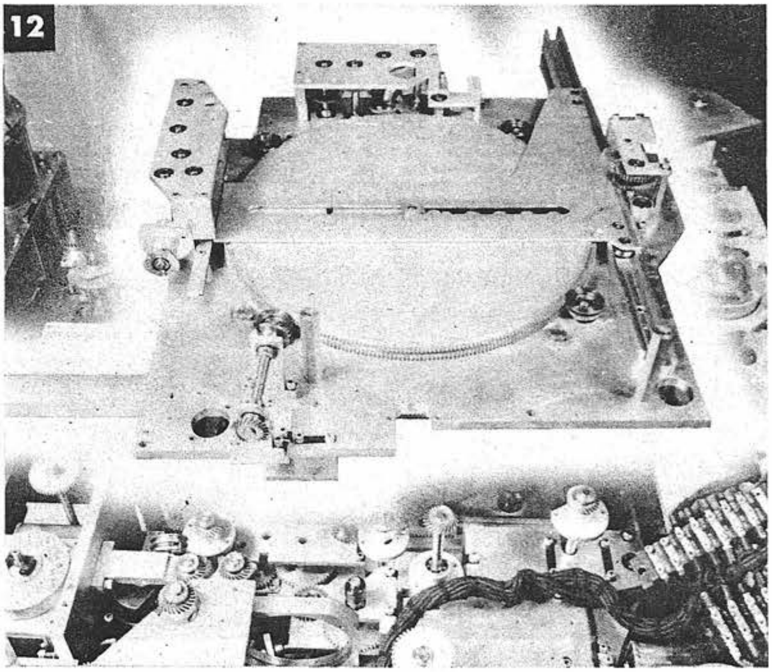
10 Remove the two screws securing the bracket between the *dRh* and *RdBs* follow-ups. Remove the bracket.
Unpin the collar of the bevel gear indicated. Remove the gear.
Remove the screws securing the bevel gear hanger.
Remove the hanger.



11 Remove the two screws securing an adapter to the under side of the height computer plate. Remove the screws securing the plate to the instrument.



12 Lift the plate straight up and remove the mechanism.

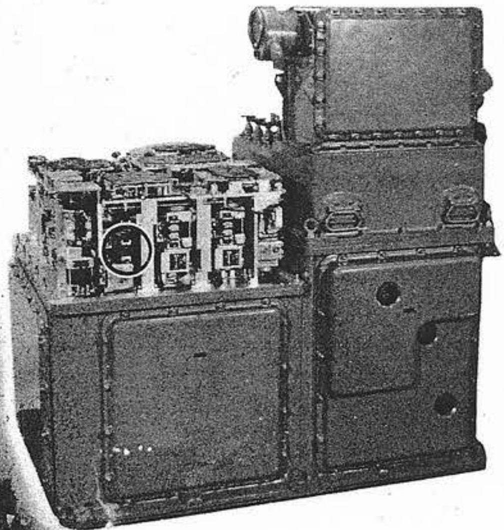


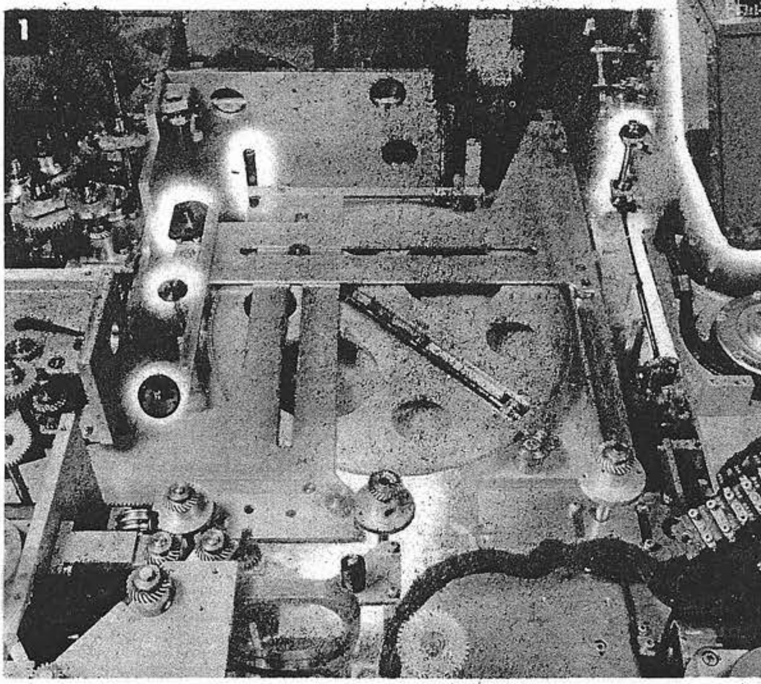
To reinstall the mechanism, reverse the removal procedure.

For readjustment procedure, follow the directions given for the reinstallation of the top plate, page 644 to 651, and run tests accordingly.

dH, dRh COMPONENT SOLVERS

Top Plate of the Control Unit, page 644
Target Solver, page 652
Height Solver, page 652
dR Follow-up, page 591



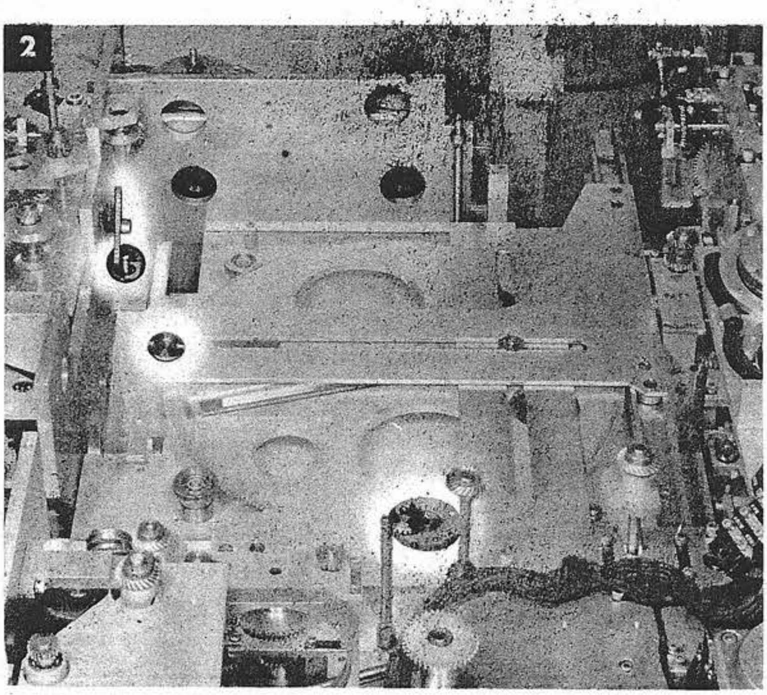


1 Remove the eight screws securing two shaft assemblies to the back of the front plate of the control unit. Remove the assemblies.

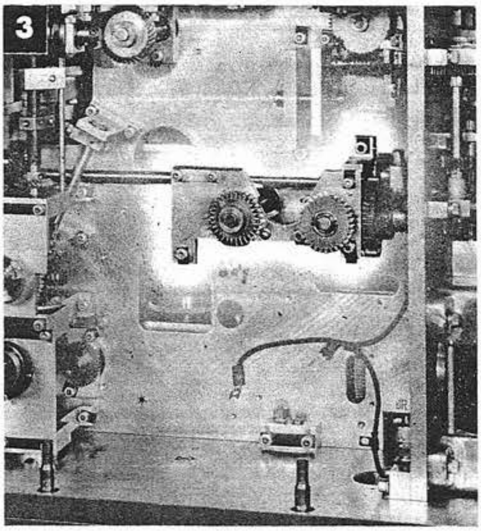
Remove the hexagonal post at the left rear corner of the plate.

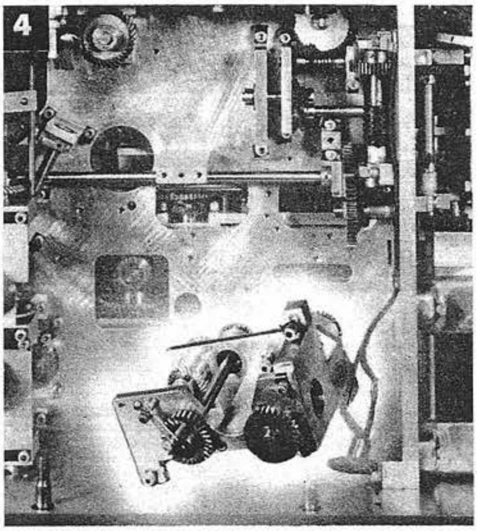
Remove the two screws securing the hanger for the *Ct* transmitter worm shaft. Remove the shaft assembly.

Unpin the collars of the two gears and the coupling indicated.



2 Remove these three parts and the adapter below the bevel gear.

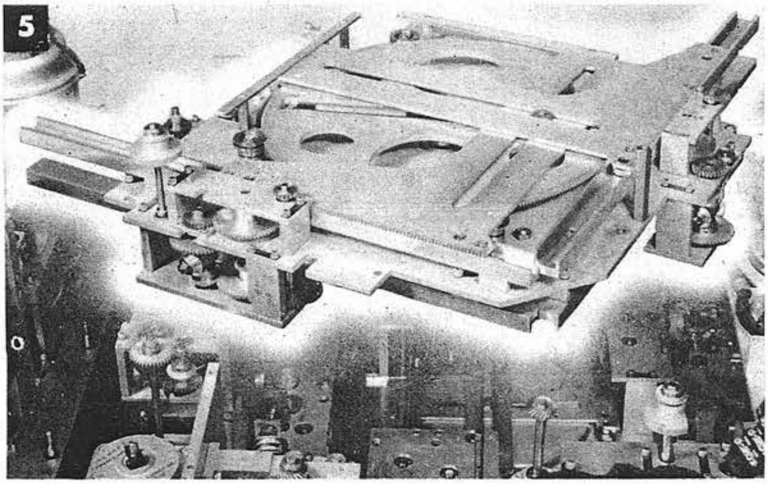




3 Remove the four screws securing the range input gearing group to the front plate of the instrument.

4 Remove the gearing group.

5 Remove the screws securing the *dH, dRh* plate. Lift out the plate with the rear edge tilted upward.



To reinstall the component solvers, reverse the removal procedure.

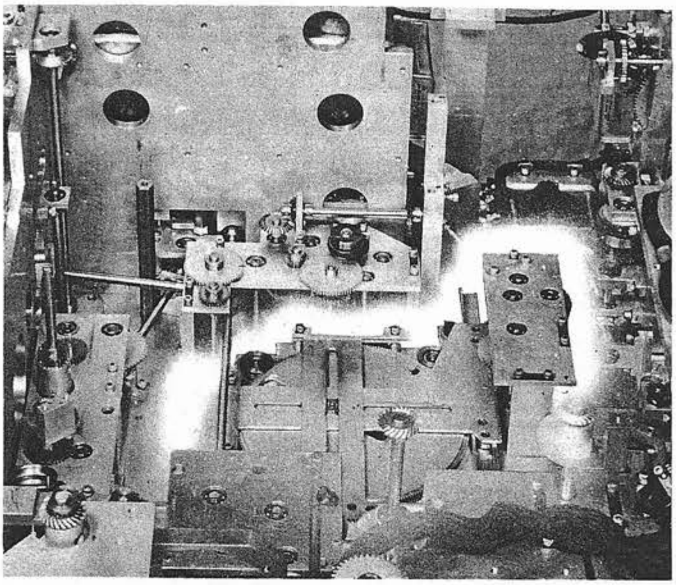
Reinstall the other mechanisms removed.

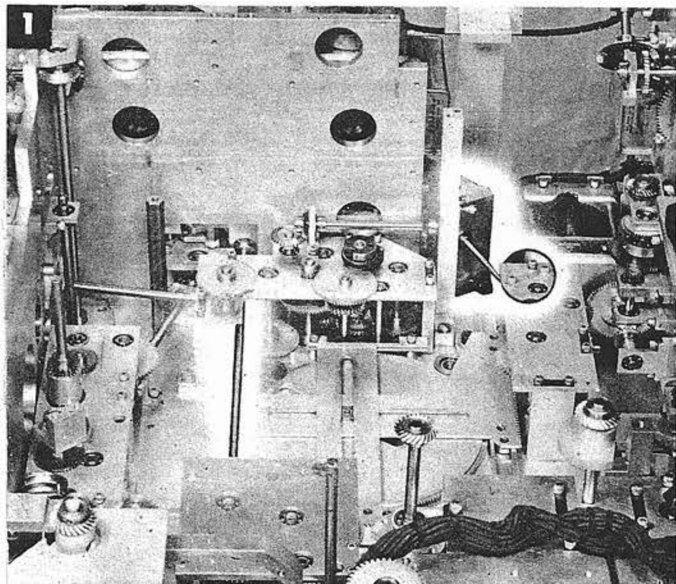
For the readjustment procedure, follow the directions given for the reinstallation of the top plate, page 651, and run tests accordingly.

SHIP COMPONENT SOLVER

Top Plate of the Control Unit, page 644

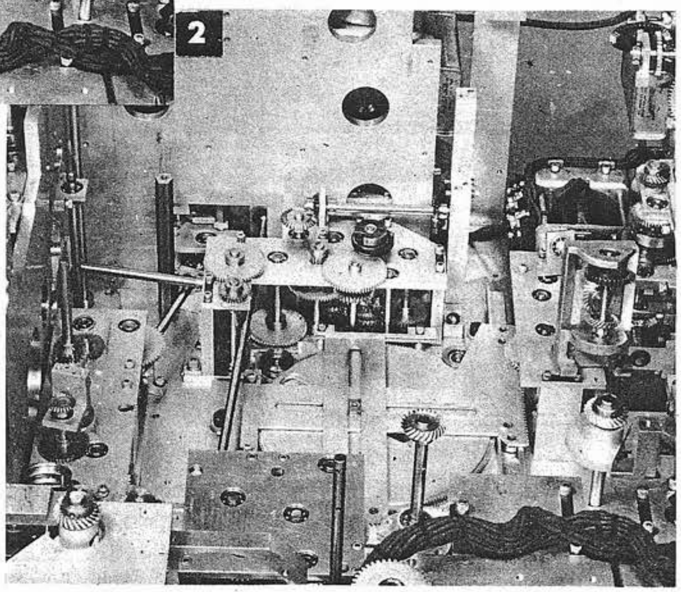
Height Solver, page 652
Target Solver, page 652
dH, dRh Solvers, page 656





1 Remove the four screws securing a long shaft assembly at the rear of the ship component solver. Move the shaft assembly to the rear as far as possible.

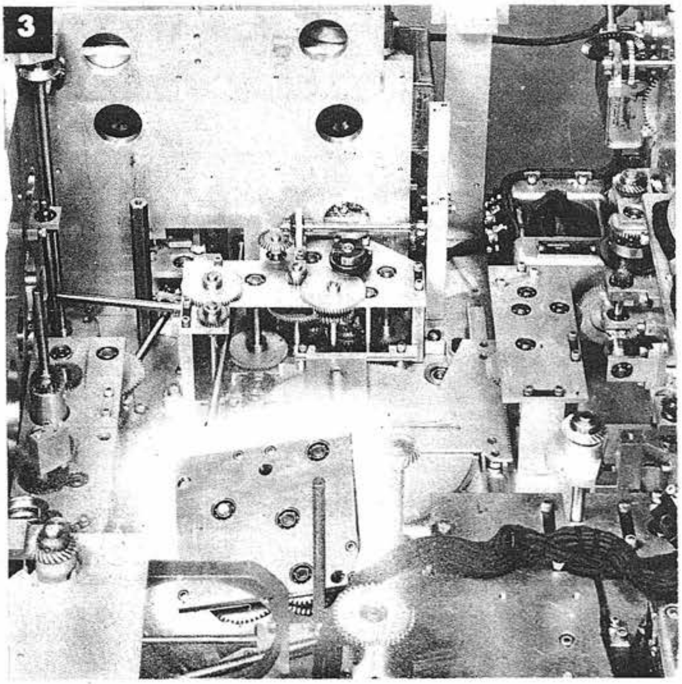
Remove the four screws securing a shaft assembly near the *RdBs* follow-up.



2 Remove the assembly.

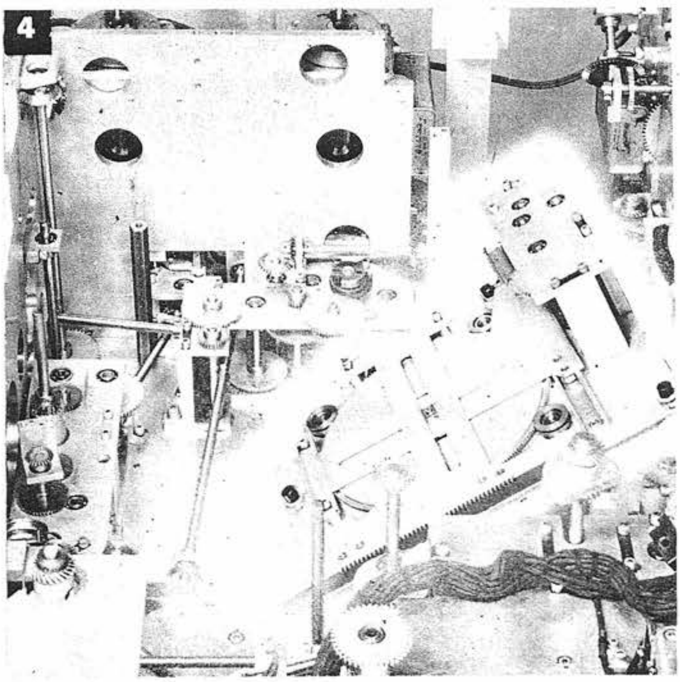
3 Remove the four screws securing a small square gearing mechanism next to the ship component solver. Remove the screws from the lower plate by reaching through the access holes in the top plate.

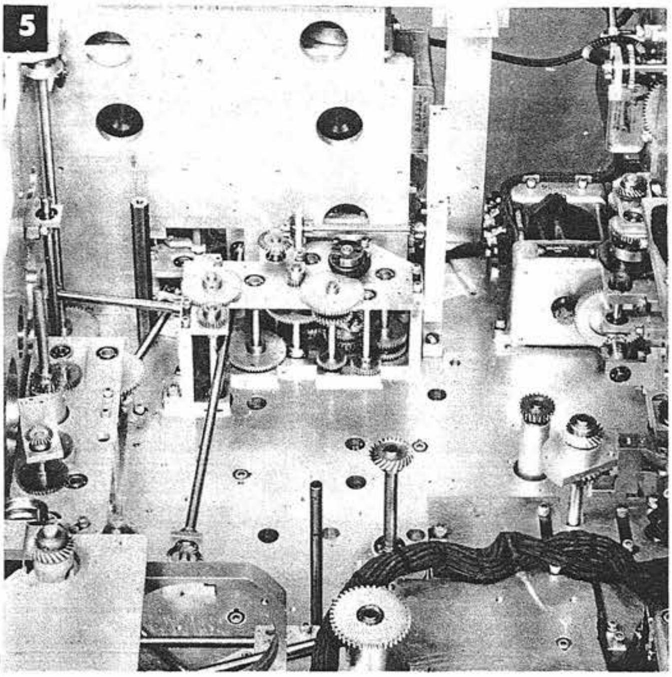
Remove the mechanism.



4 Remove the screws securing the ship component solver mounting plate to the base of the control unit. Work the dowels free.

Tilt the unit to clear.





5 Remove the mechanism.

To reinstall the ship component solver, reverse the removal procedure.

Reinstall the *dH, dRh* component solvers, the height and target component solvers, the top plate, and associated mechanisms.

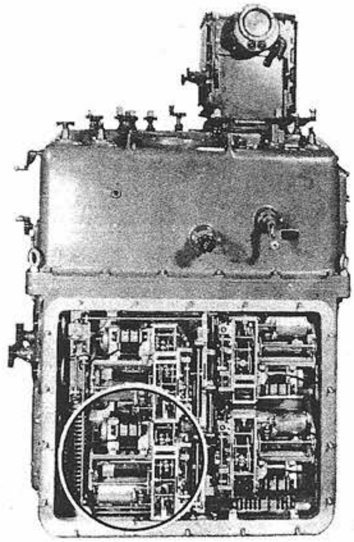
Follow the readjustment procedure for the reinstallation of the top plate, page 651, and run tests accordingly.

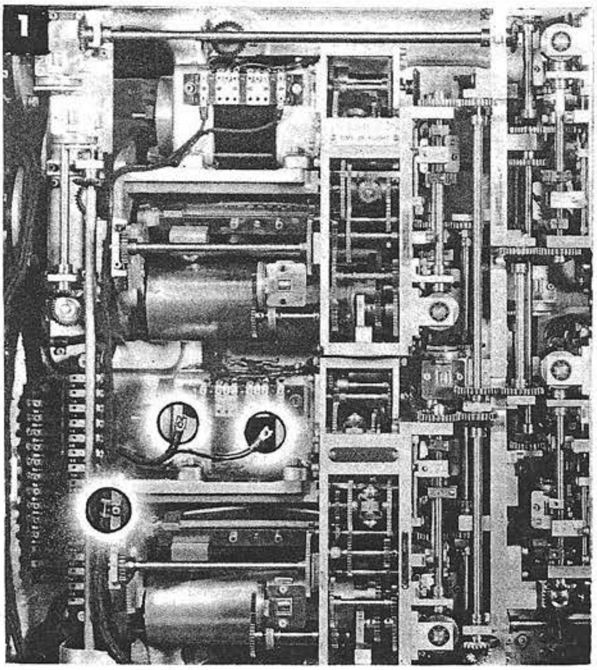
Computer Unit

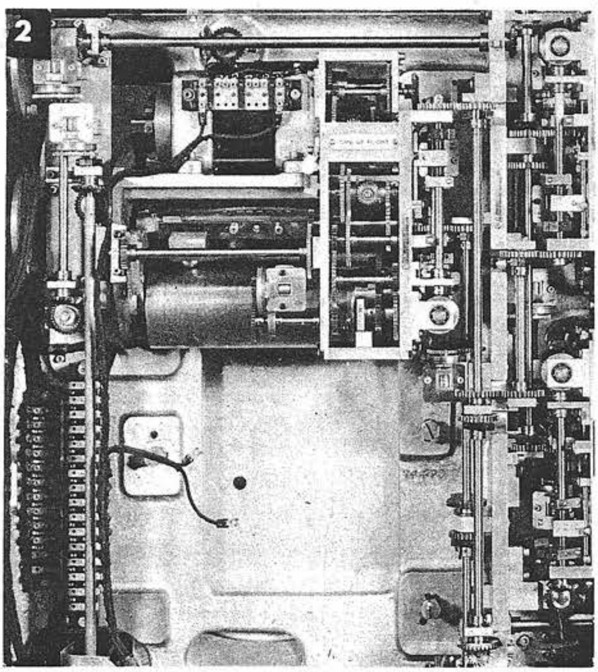
This unit includes the four ballistic computer units, the integrator group, the prediction section, the *Co* receiver, and the $\triangle cB'r$ and $\triangle cEb$ transmitters.

 Table of Contents

Vf + Pe BALLISTIC COMPUTER







1 Remove the two screws connecting cable leads C and CC to the servo terminal block.
Loosen the screw securing the cable clamp to the side of the mechanism.
Free the cable.

2 Remove the three large screws securing the ballistic computer and remove it.

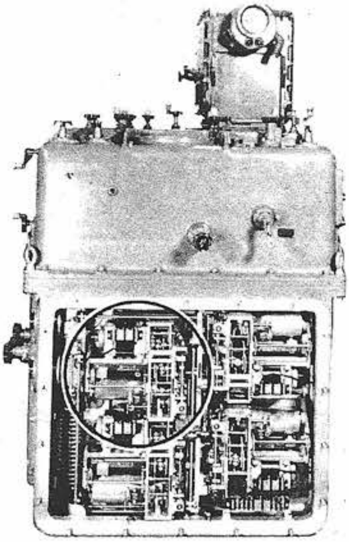
To reinstall the *Vf* + *Pe* ballistic computer, position the mechanism by means of the dowels and reverse the removal procedure.

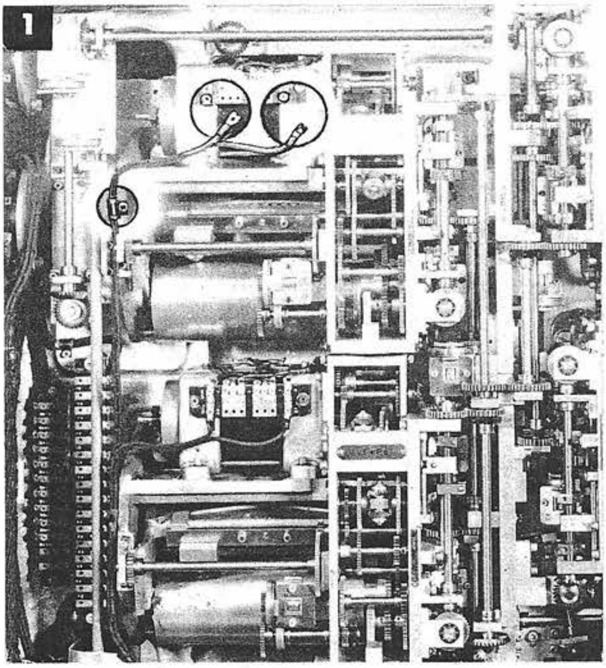
Readjust clamps A-85, A-82 and A-75.

Run tests.

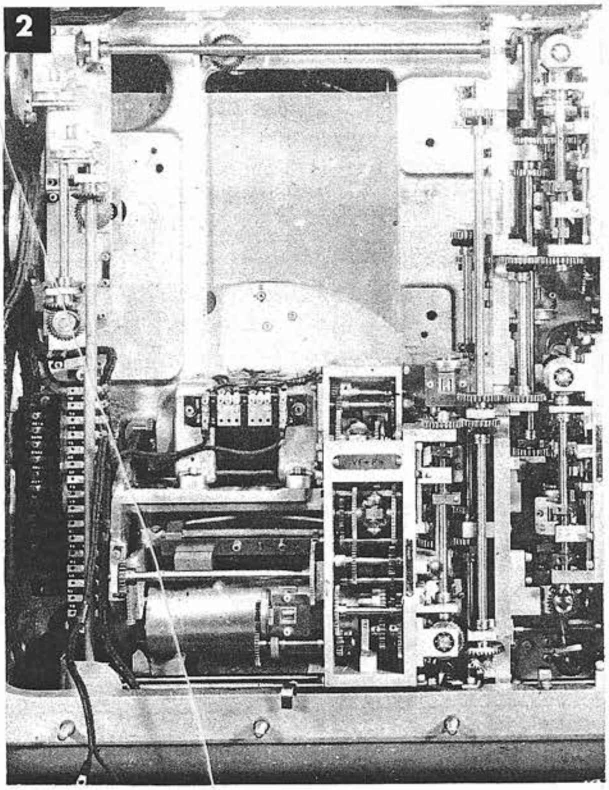
Gene Slover's US Navy Pages Table of Contents

Tf BALLISTIC COMPUTER





1 Remove the two screws connecting cable leads A and AA to the servo terminal block.
Loosen the screw securing the cable clamp to the side of the ballistic computer. Free the cable.



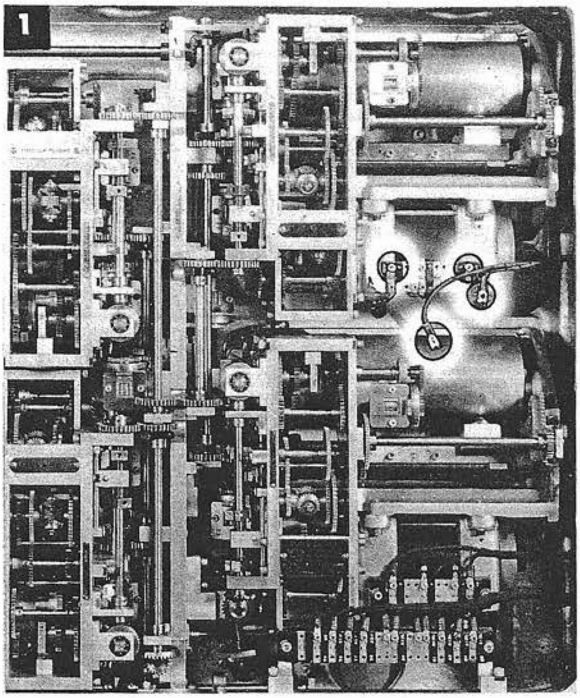
2 Remove the three screws securing the mechanism and remove it.

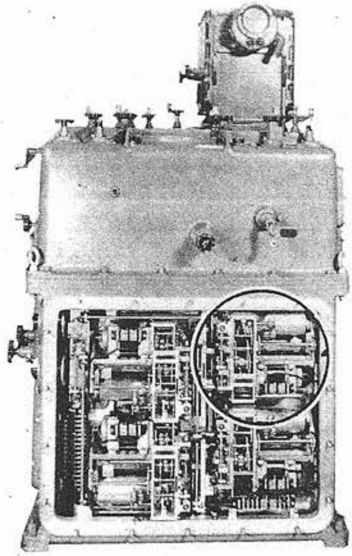
To reinstall the *Tf* ballistic computer, position the mechanism by means of the dowels and reverse the removal procedure.

Readjust clamps A-84, A-74, and A-80.

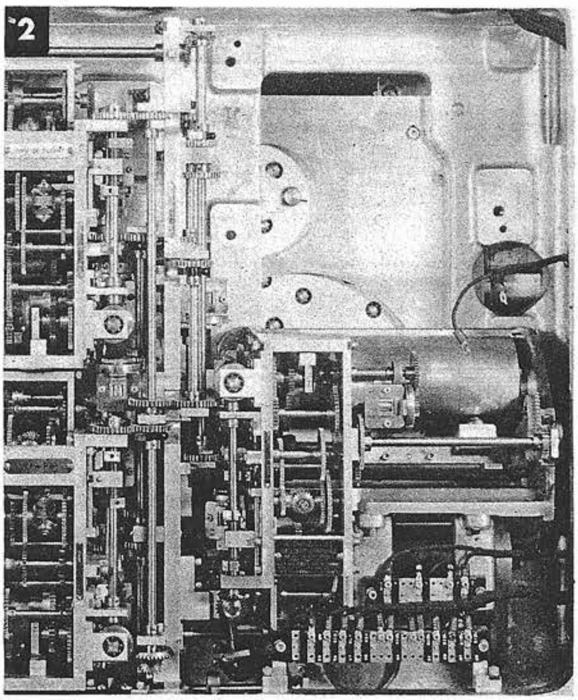
Run tests.

Tf/R2 BALLISTIC COMPUTER





1 Remove the two screws connecting cable leads B and BB to the servo terminal block.



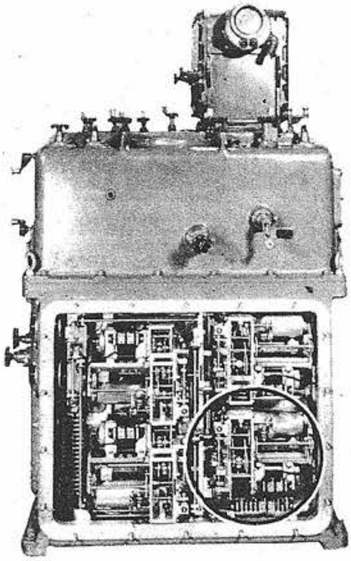
2 Remove the three screws securing the mechanism and remove it.

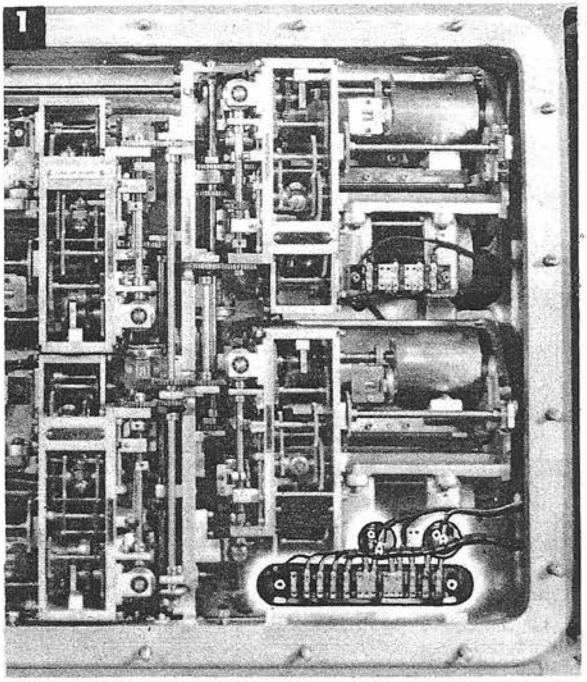
To reinstall the *Tf/R2* ballistic computer, position the mechanism by means of the dowels and reverse the removal procedure.

Readjust clamps A-76, A-71, and A-78.

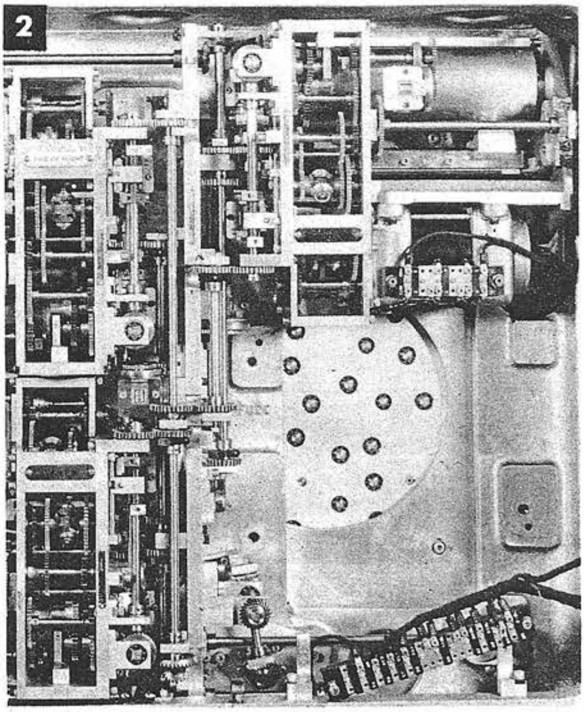
Run tests.

FUZE BALLISTIC COMPUTER





1 Remove the two screws connecting cable leads D and DD to the servo terminal block.
Remove the two screws securing the terminal block just below the fuze ballistic computer. Move the terminal block out of the way.



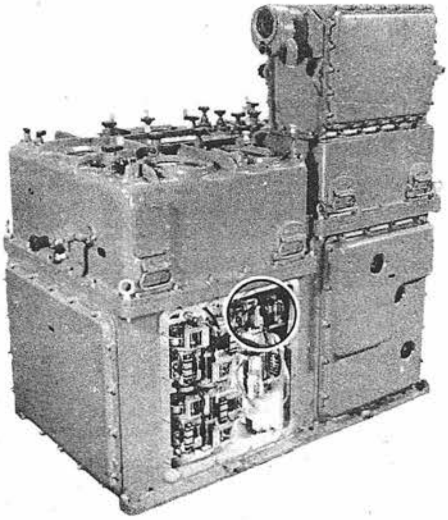
2 Remove the three screws securing the mechanism and remove it.

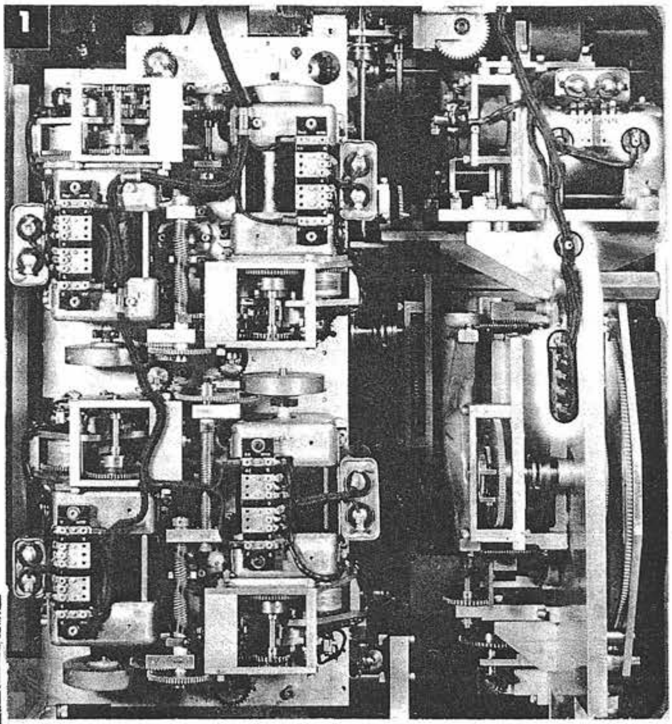
To reinstall the fuze ballistic computer, position the mechanism by means of the dowels and reverse the removal procedure.

Readjust clamps A-73, A-203, and A-77.

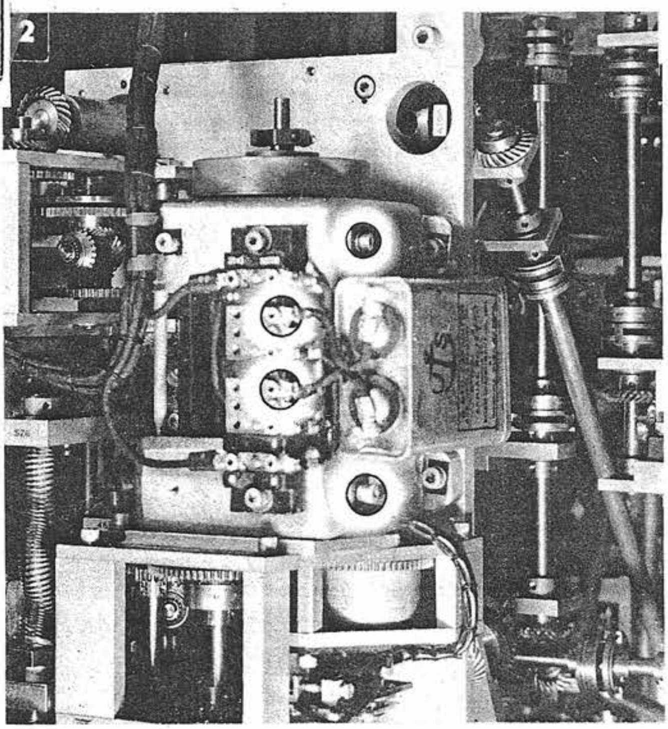
Run tests.

Co RECEIVER AND MOUNTING PLATE



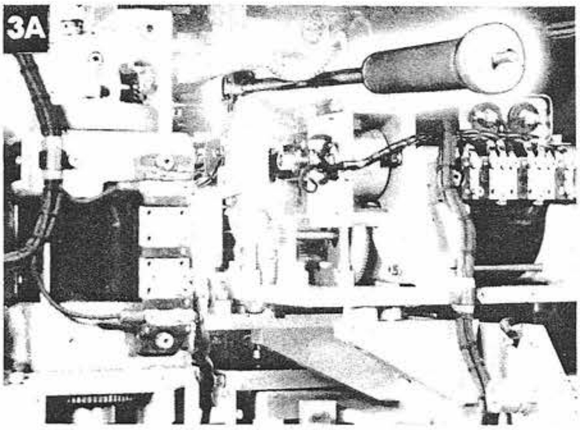


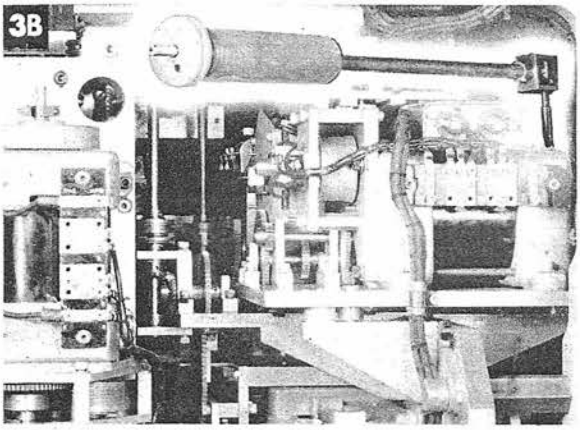
1 Remove the two screws connecting cable leads U and UU to the servo terminal block of the *Co* receiver. Remove the five screws connecting the *Co* leads to the terminal block below the receiver. Loosen the screw securing the cable clamp above the terminal block. Free the cable.

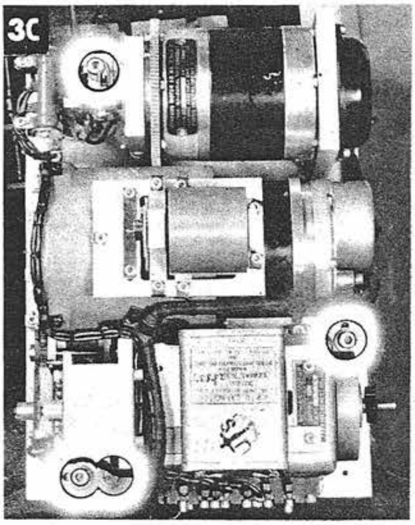


2 Remove the two screws connecting the capacitor leads to the servo terminal block of the *Dtwj* follow-up. Remove the two screws securing the capacitor and remove it.

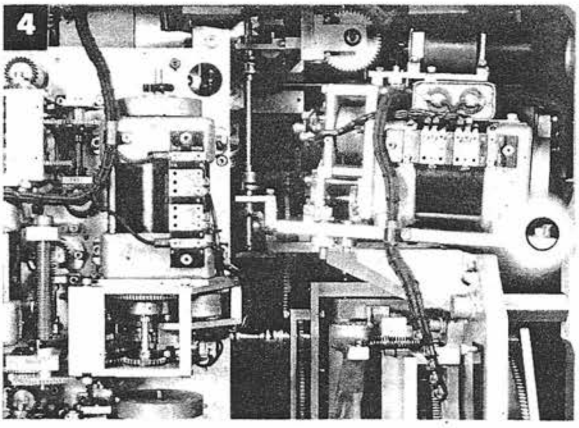
Gene Slover's US Navy Pages
Table of Contents

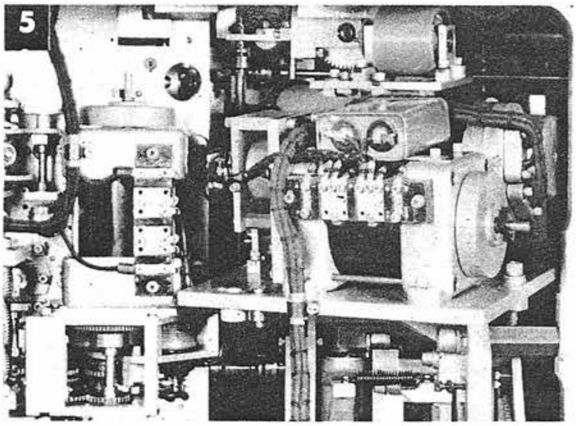
3A


3B


3C


3 Using an angle screw driver, loosen the three screws securing the *Co* receiver to its mounting plate. Do not remove the screws from the *Co* mounting plate for they are difficult to reach and may drop into the mechanism.

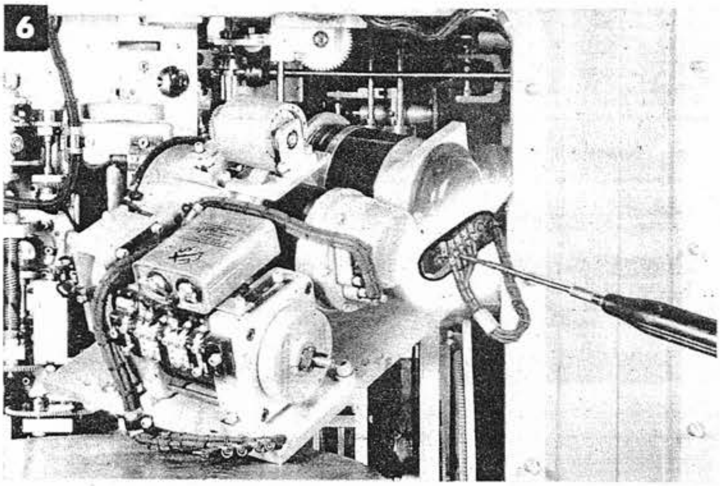
4


5


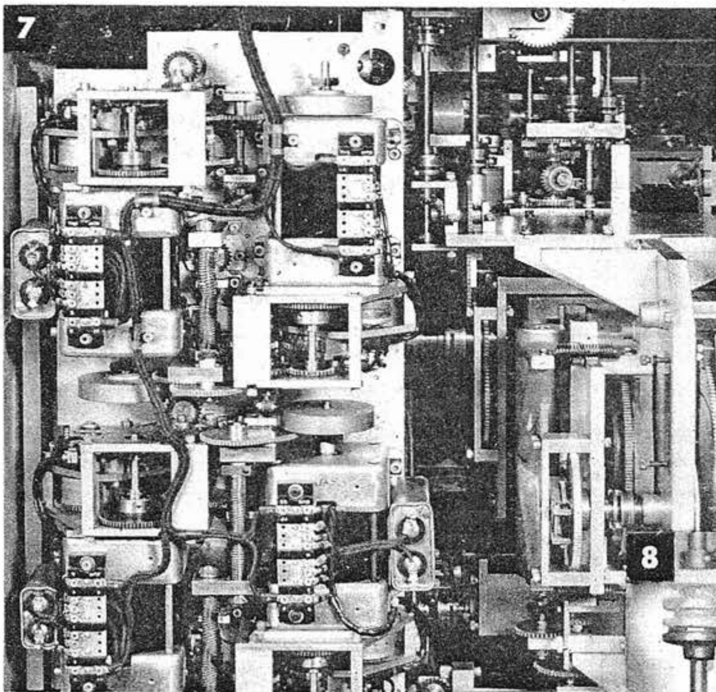
4 Lift the receiver to disengage the dowels and move it out slightly to reach a cable clamp at the right rear corner. Remove the screw and the cable clamp.

5 Pull the receiver out a little more to reach the screw securing the cable clamp behind the fine synchro. Remove the screw and the clamp carefully.

Table of Contents



6 Ease the receiver out still farther to reach the five screws connecting the cable leads to the synchro terminal block. Remove the five screws.



7 Remove the receiver.

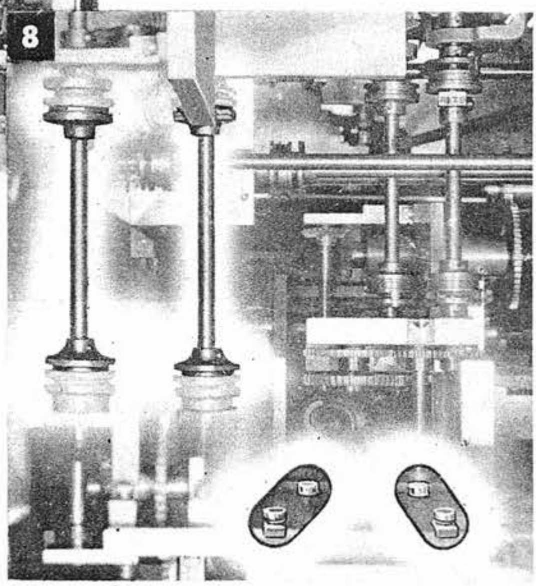
To reinstall the *Co* receiver, reverse the removal procedure.

Readjust clamp A-179.

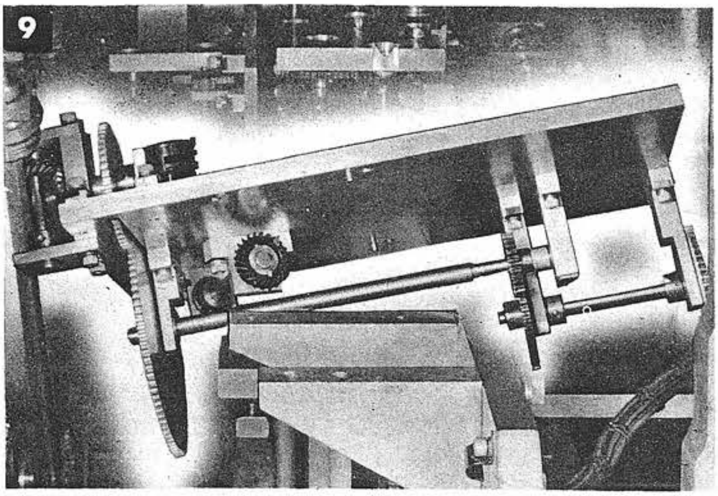
Run transmission tests.

When the *Co* receiver is removed to gain access to other mechanisms, it is sometimes desirable to remove the mounting plate below the receiver.

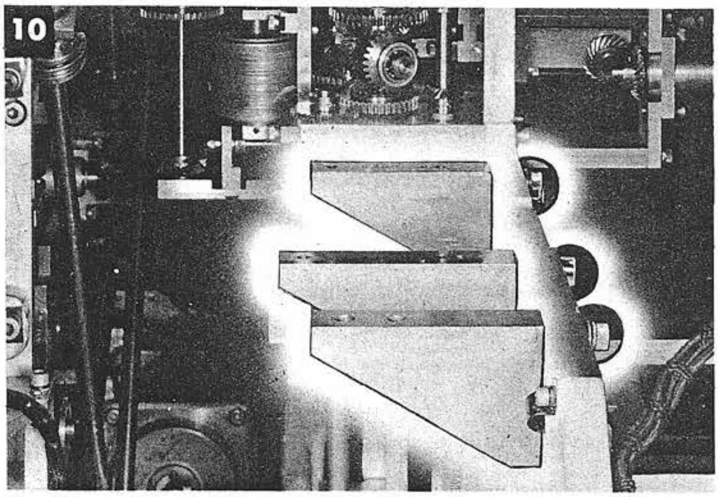
8 Remove the locking spring from the coupling shaft in the time line. Remove the shaft.
Remove the locking spring from the coupling shaft in the *cR* line. Remove the shaft.
Remove the four screws securing the plate.



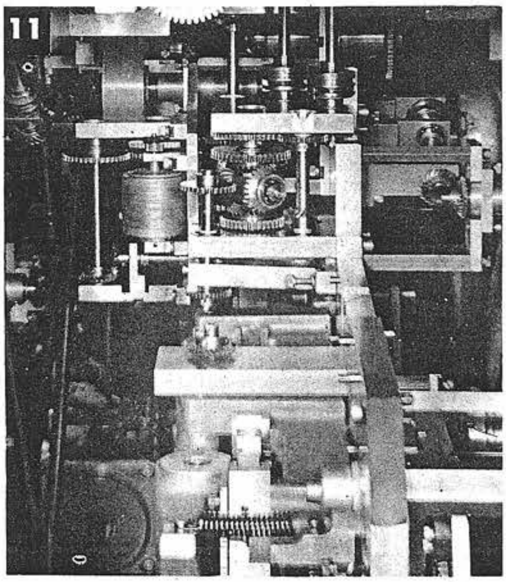
9 Tilt the plate and remove it.



10 To increase the working space, remove the two screws securing each supporting bracket.



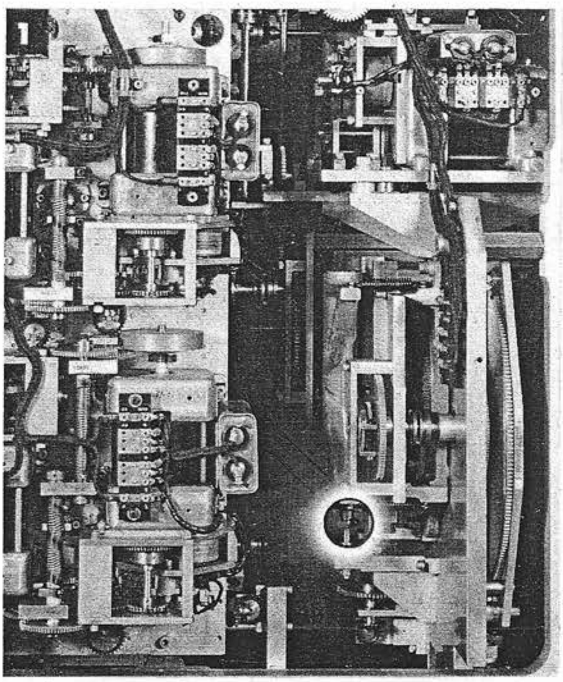
11 Remove the brackets.

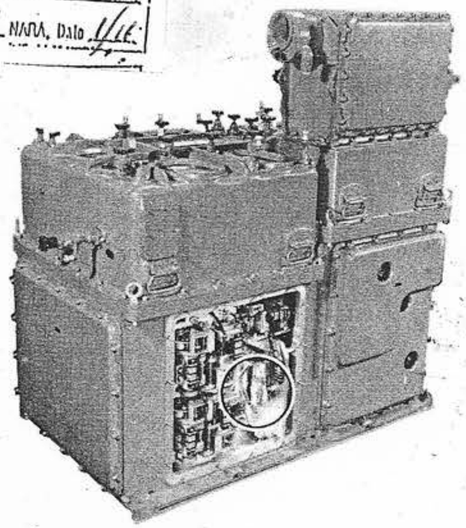


To reinstall the brackets and the plate, reverse the removal procedure. When reinstalling the *cR* coupling shaft, position it to establish the proper relationship between the *cR* dials and the *cR* intermittent drive.

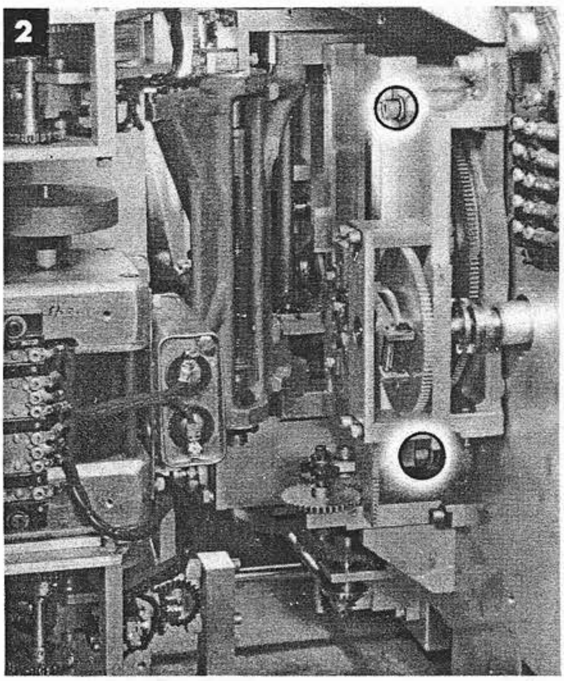
Reinstall the *Co* receiver.

1/cR VERNIER ASSEMBLY

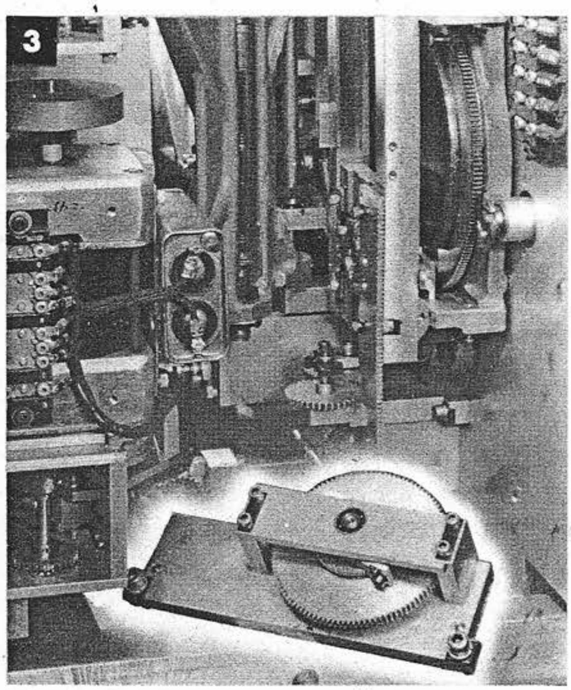




1 Loosen clamp A-142. Slide the coupling along the shaft so that the 1/*cR* integrator can be opened.



2 Remove the two springs. Remove the two balls carefully.
Remove the two screws securing the vernier assembly to the integrator



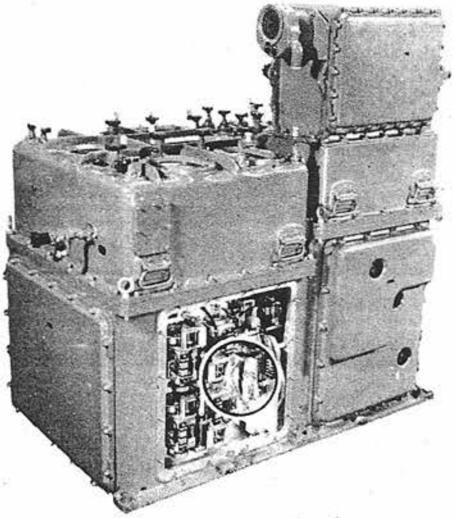
3 Remove the vernier assembly.

To reinstall the 1/*cR* vernier assembly, reverse the removal procedure.

Readjust clamps A-149 and A-150.

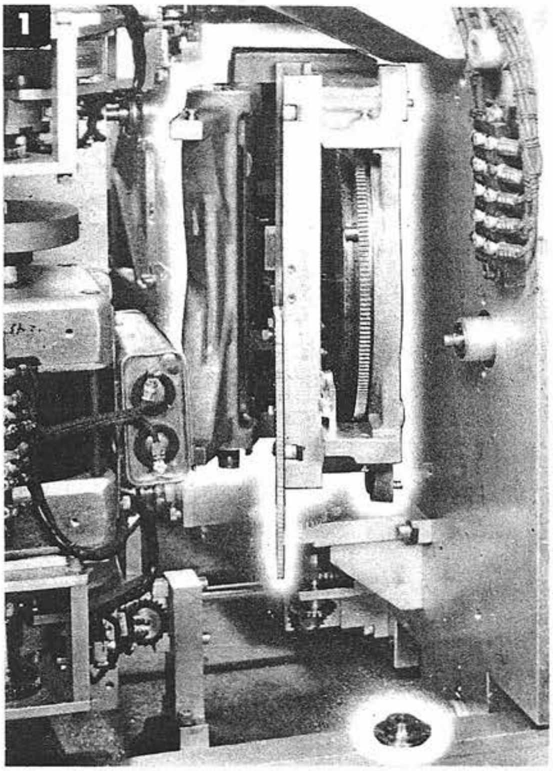
Run tests.

Table of Contents

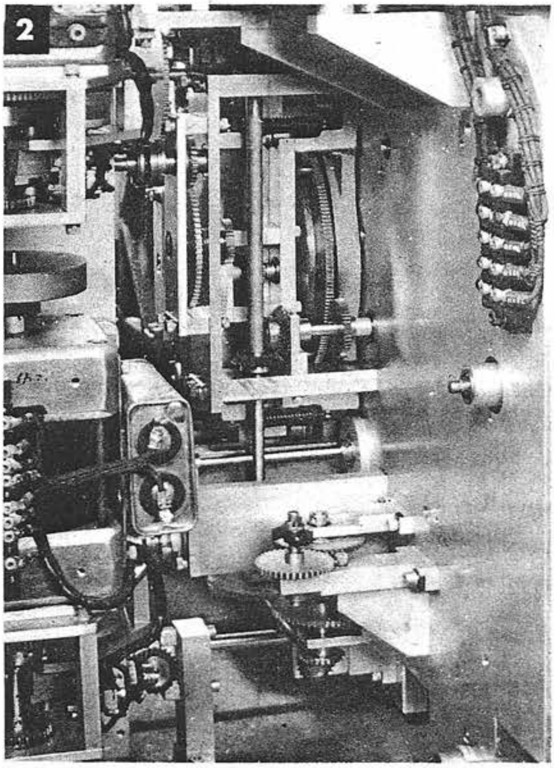


1/cR INTEGRATOR

1/*cR* Vernier Assembly, page 670



1 Remove the three large screws securing the integrator. Use a socket head screw wrench to remove the screw at the upper rear corner of the integrator casting.



2 Work the dowels loose from the mounting plate. Unpin the coupling of the 1/*cR* vernier assembly. Remove the coupling.

NOTE: Usually the integrator can be removed without removing the coupling of the 1/*cR* vernier assembly.

Remove the mechanism.

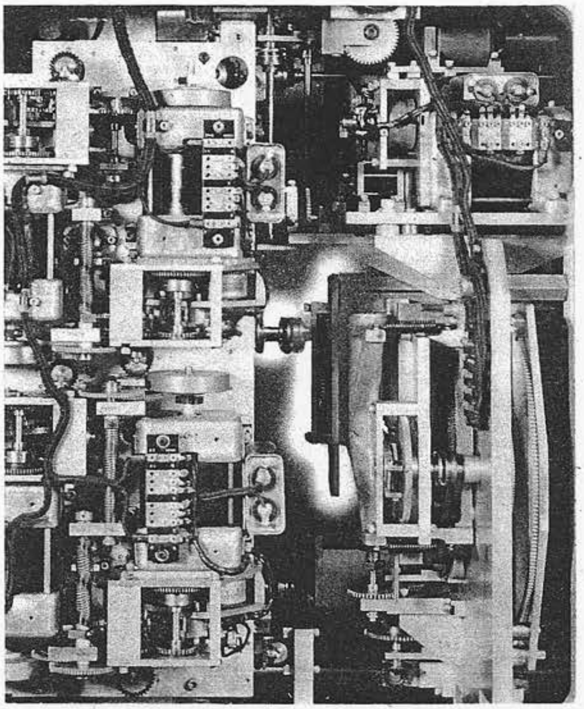
To reinstall the 1/*cR* integrator, reverse the removal procedure.

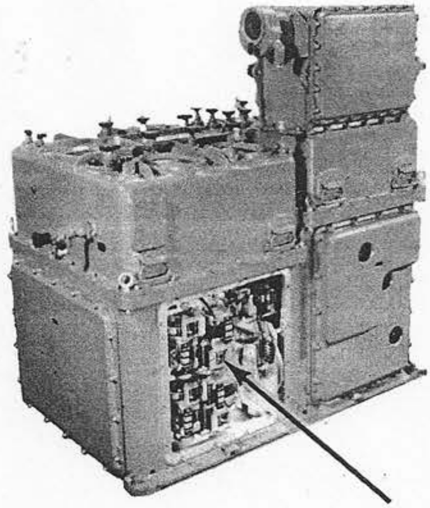
Reinstall the 1/*cR* vernier assembly.

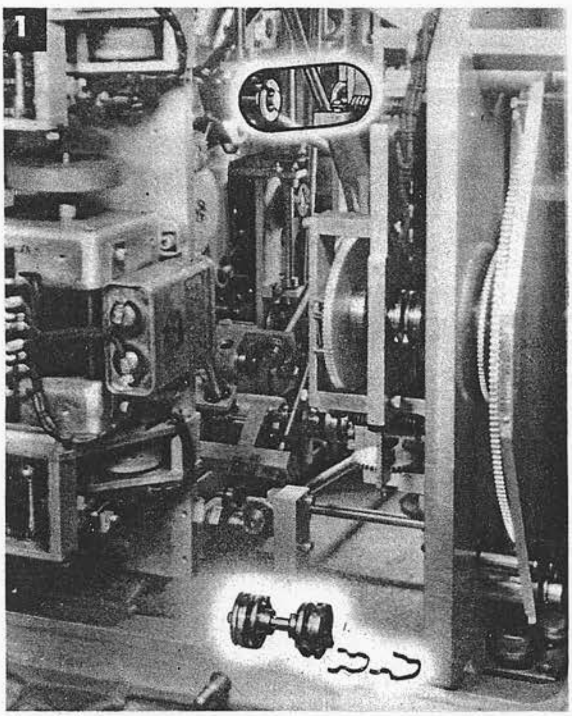
Readjust clamps A-149 and A-150.

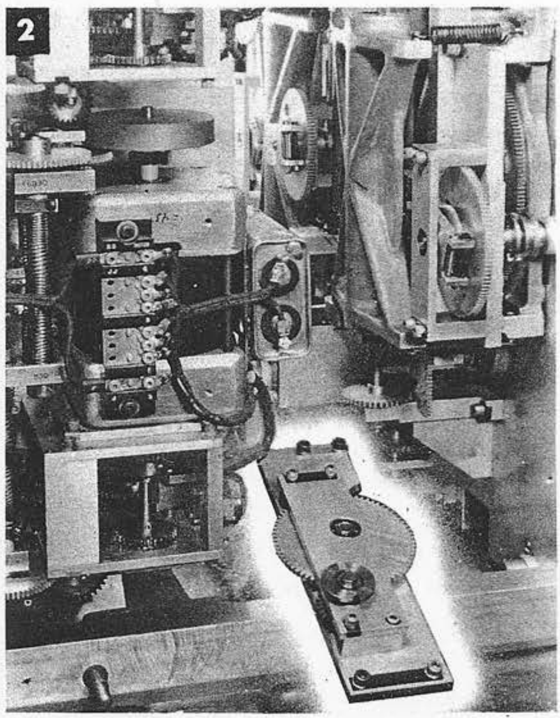
Run tests.

RdBs VERNIER ASSEMBLY



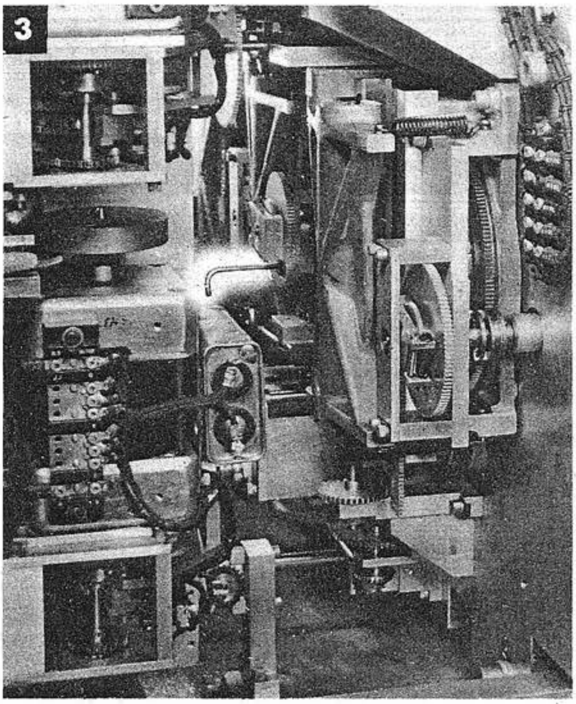




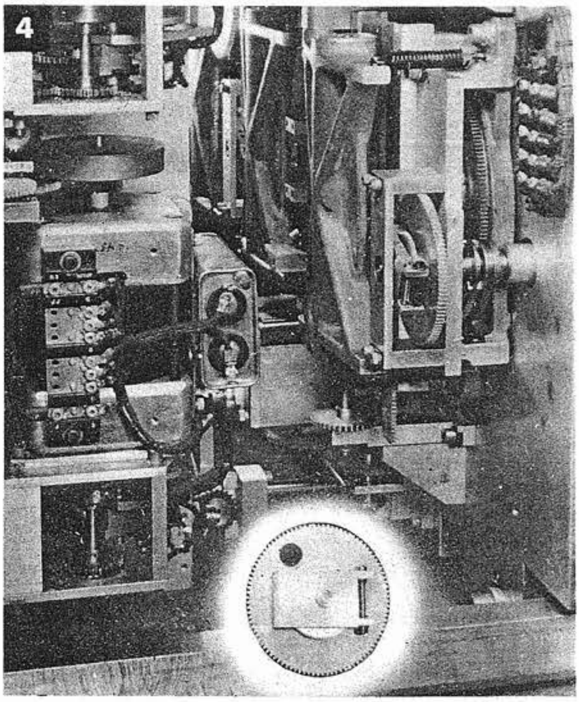


1 Remove the locking springs from the short coupling shaft in the *RdBs* line next to the vernier assembly. Remove the shaft.

2 Remove the four screws securing the plate and associated gearing at the rear of the coupling just removed. Remove the plate.



3 Remove the four screws securing the plate behind the vernier. These screws can be reached through the access hole in the vernier gear.



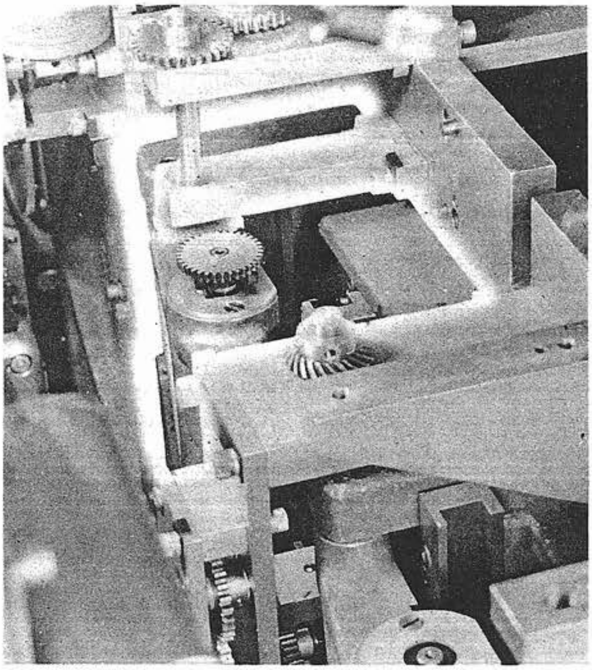
4 Remove the *RdBs* vernier assembly.

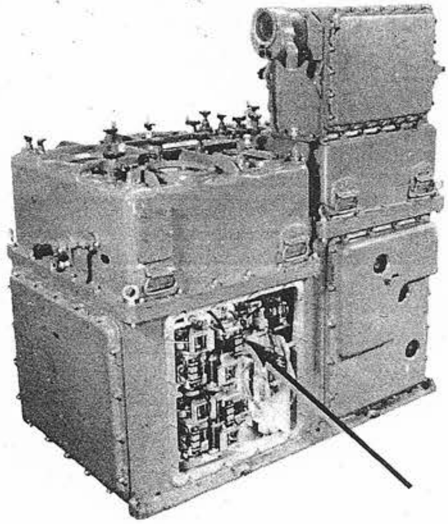
To reinstall the *RdBs* vernier assembly, reverse the removal procedure.

Readjust clamps A-139 and A-140.

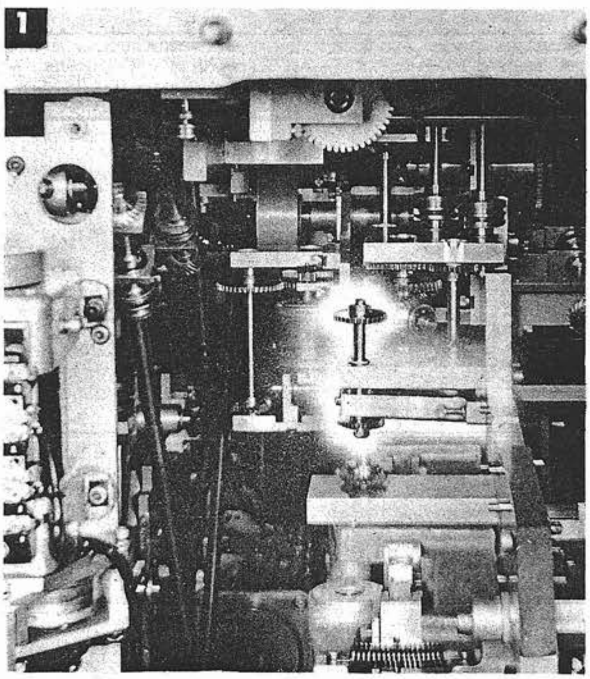
Run tests.

RdBs INTEGRATOR

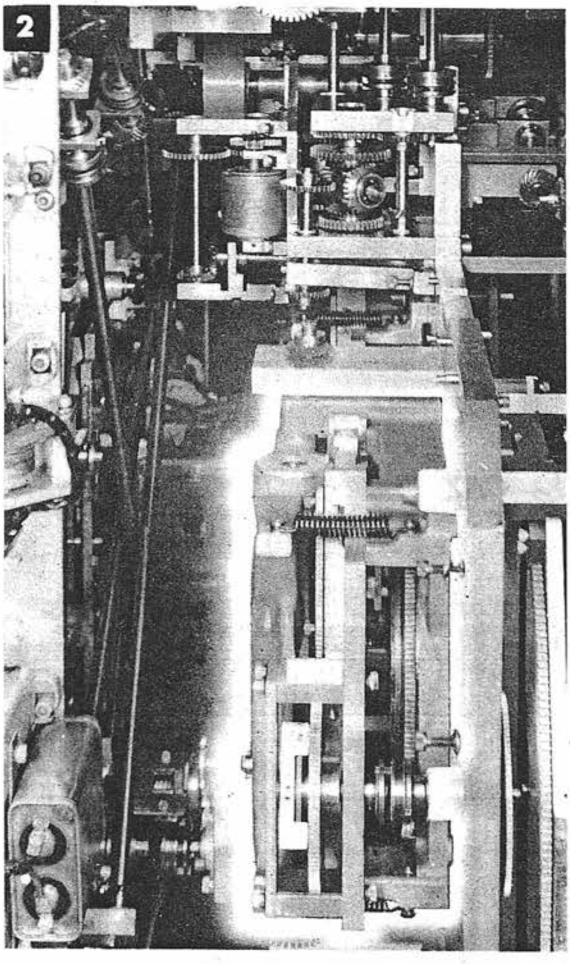


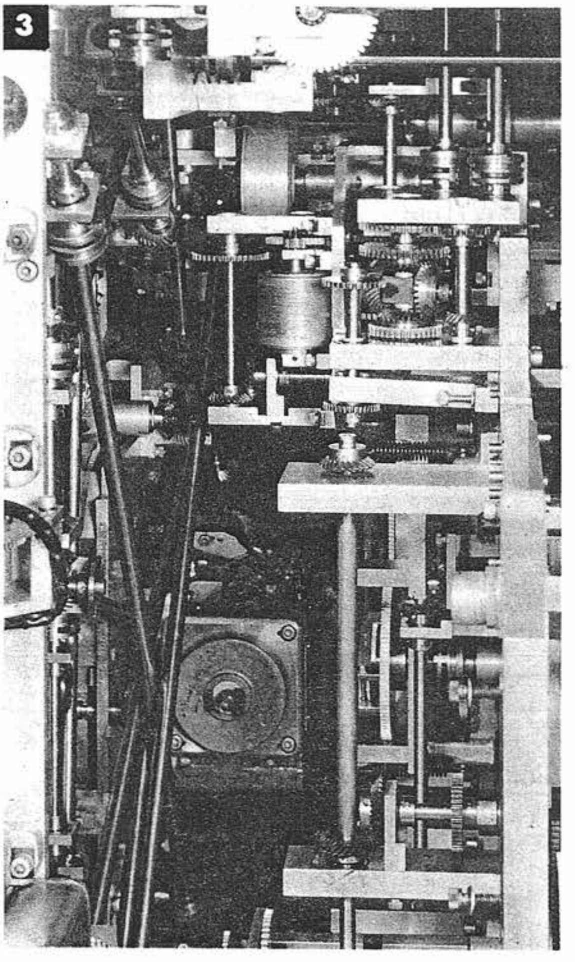


Co Receiver and Mounting Plate, page 666
1/*cR* Vernier Assembly, page 670
1/*cR* Integrator, page 671
RdBs Vernier Assembly, page 672



1 Remove the two screws securing the lower hanger of the vertical shaft assembly connecting with the *RdBs* integrator output gear. Raise the shaft as far as it will go.





2 Remove the three screws securing the integrator.
Work the dowels loose.

3 Remove the integrator through the space cleared by the removal of the *Co* receiver and plate.

To reinstall the integrator, reverse the removal procedure. Reinstall all the other mechanisms removed.

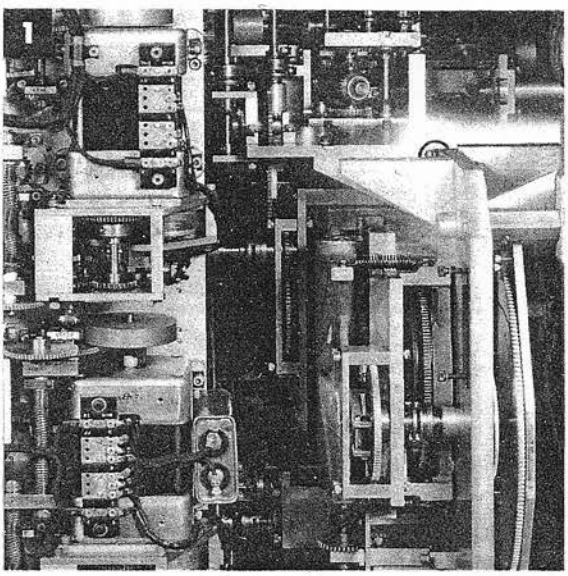
Readjust the *cR* intermittent drive through the coupling shaft.

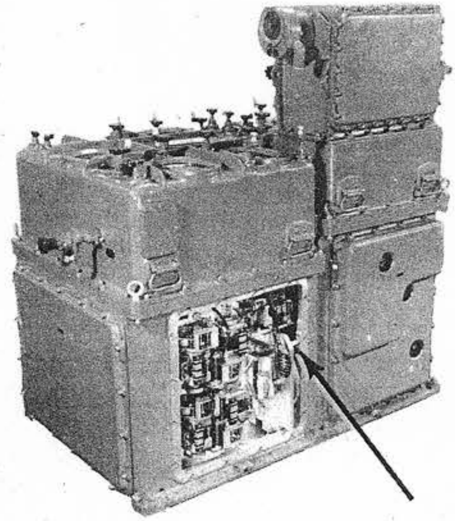
Readjust clamps A-139, A-140, A-149, A-150, and A-179.

Run tests.

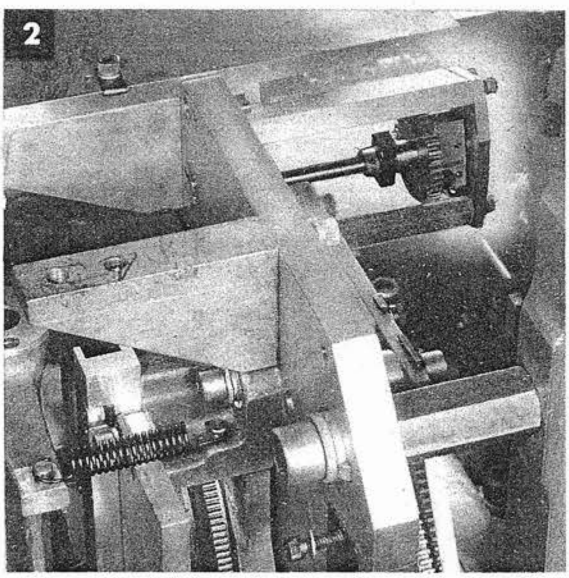
cR VERNIER ASSEMBLY

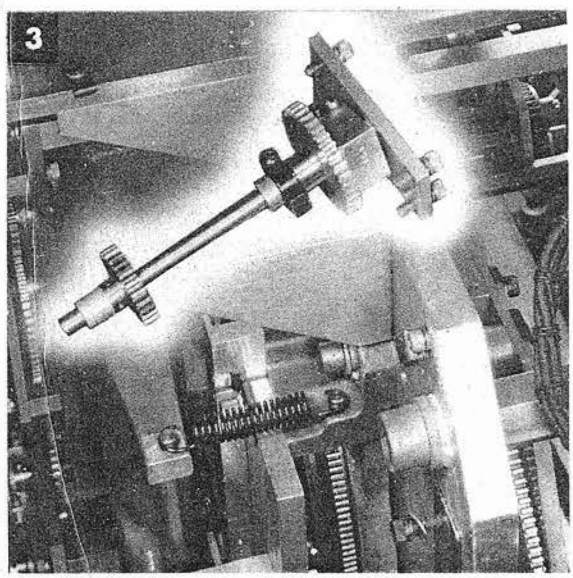
Co Receiver and Mounting Plate, page 666





1 Remove the two screws securing the rear supporting bracket for the *Co* receiver. Remove the bracket.





2 Remove the three screws securing the small plate for the *cR* vernier assembly.

3 Remove the assembly with the plate. There is a spacer on the end of the shaft.

To reinstall the *cR* vernier assembly, reverse the removal procedure.

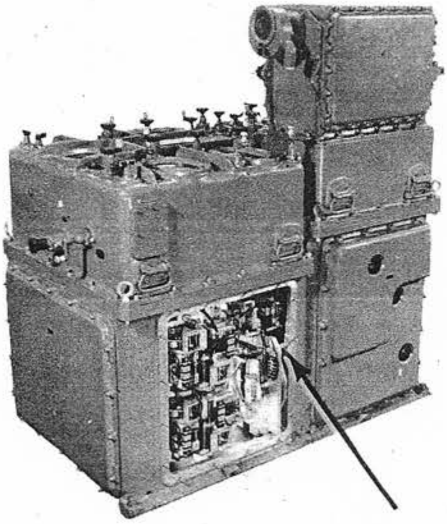
Readjust clamps A-151 and A-152.

Run tests.

Reinstall the *Co* receiver. Readjust clamp A-179.

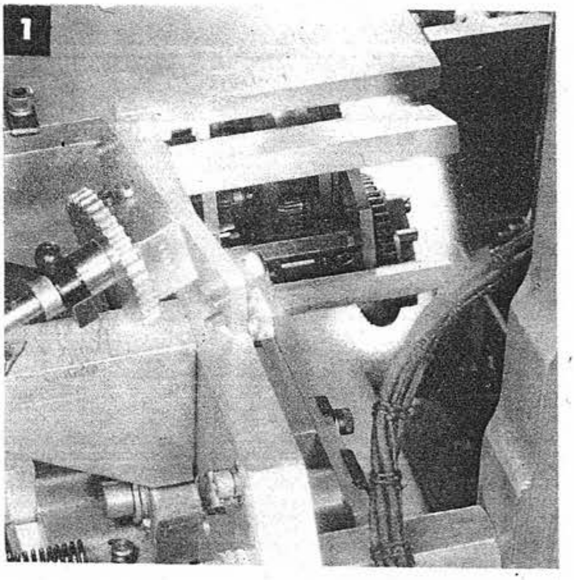
Run transmission tests.

Gene Slover's US Navy Pages | Table of Contents

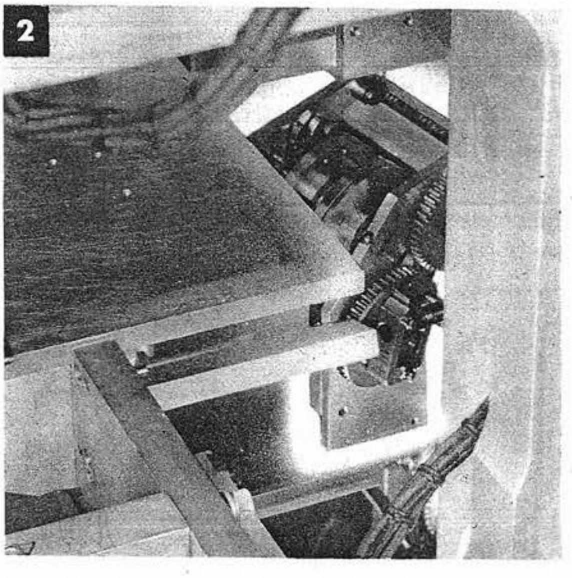


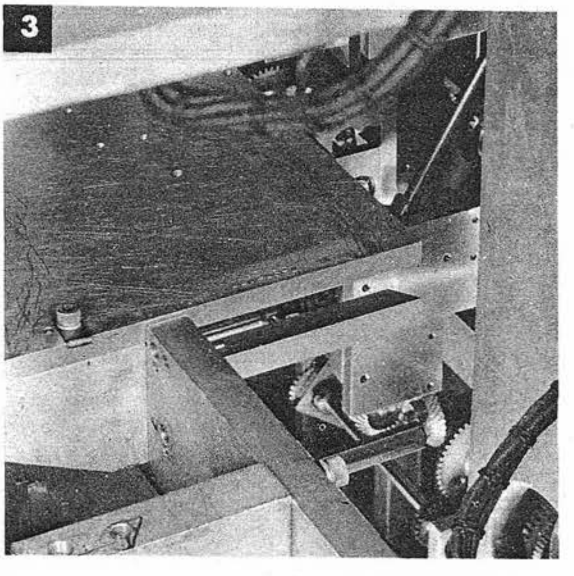
cR INTERMITTENT DRIVE

cR Vernier Assembly, page 676



1 Remove the three screws securing the intermittent drive. Hold the unit while removing the last screw.





2 Tilt the intermittent drive to clear the surrounding posts and plates.

3 Remove the *cR* intermittent drive.

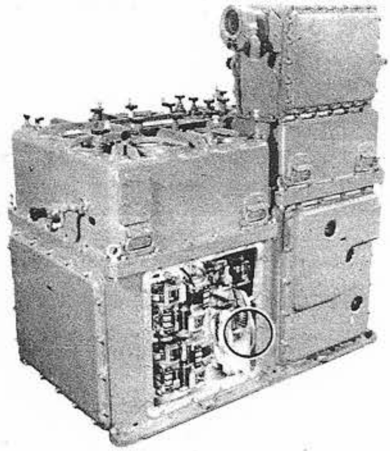
To reinstall the *cR* intermittent drive, reverse the removal procedure.

Reinstall the mechanisms removed.

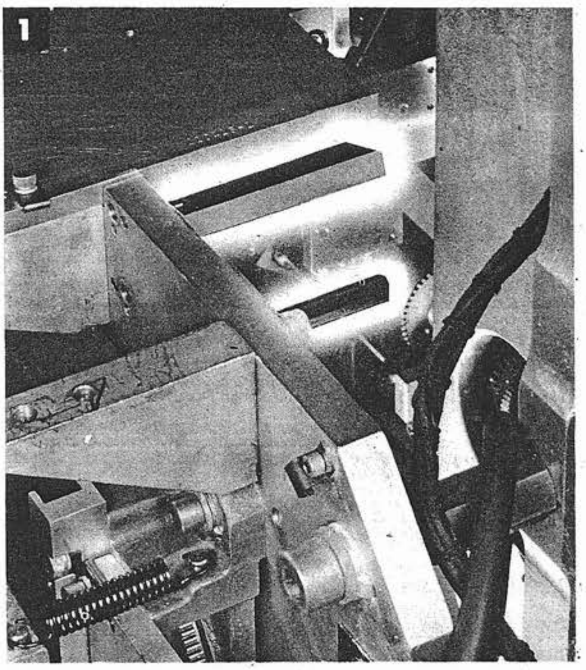
Readjust clamps A-233, A-151, A-152 and A-179.

Run tests.

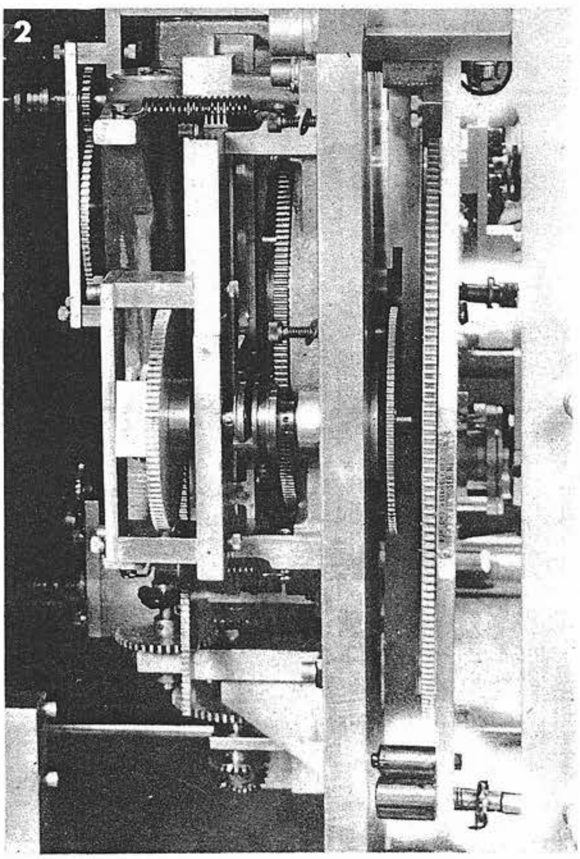
1/cR CAM



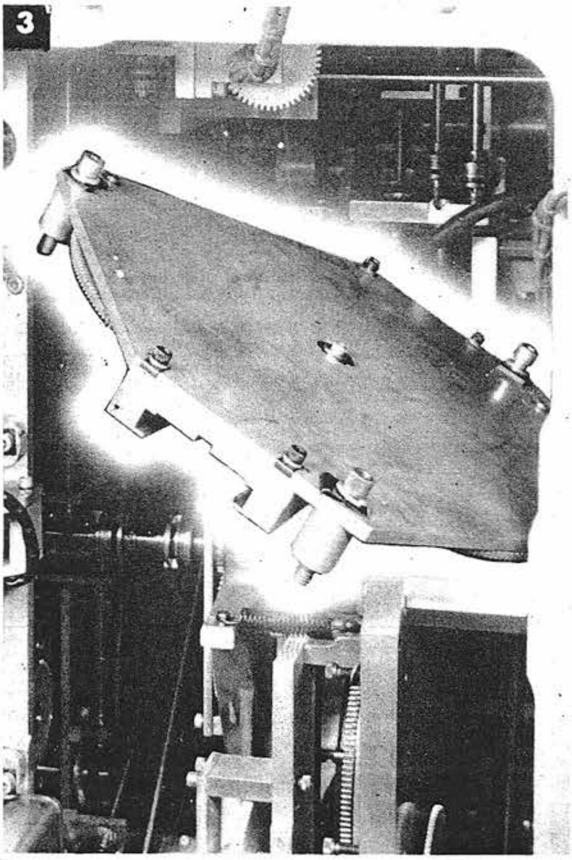
Co Receiver and Mounting Plate, page 666
cR Vernier Assembly, page 676
cR Intermittent Drive, page 677

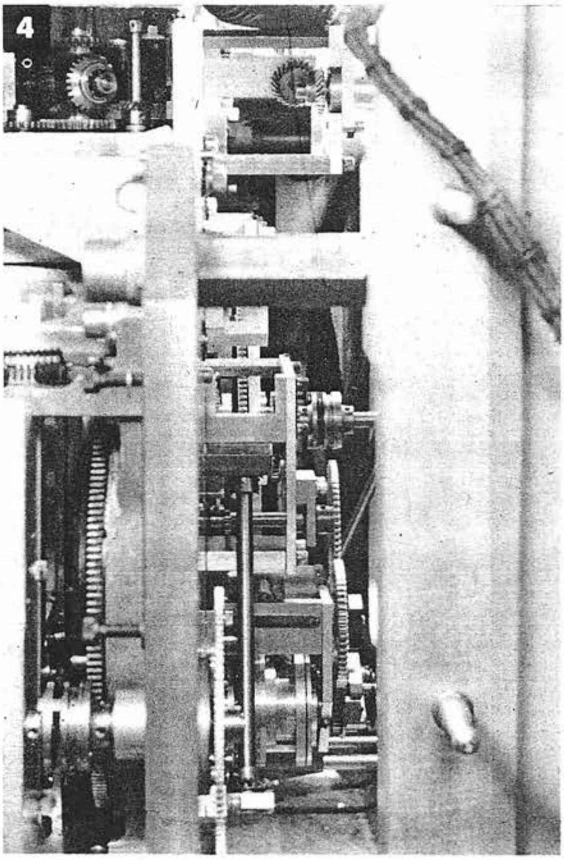


1 Remove the hexagonal post supporting the plate for the *cR* vernier assembly.
Remove the two screws securing the hanger-type post and remove it.



2 Partially back out the two screw dowels that position the 1/*cR* cam. Remove the three screws securing the cam mounting plate.





3 Tilt the mechanism upward.

4 Remove the $1/cR$ cam.

To reinstall the $1/cR$ cam, reverse the removal procedure.

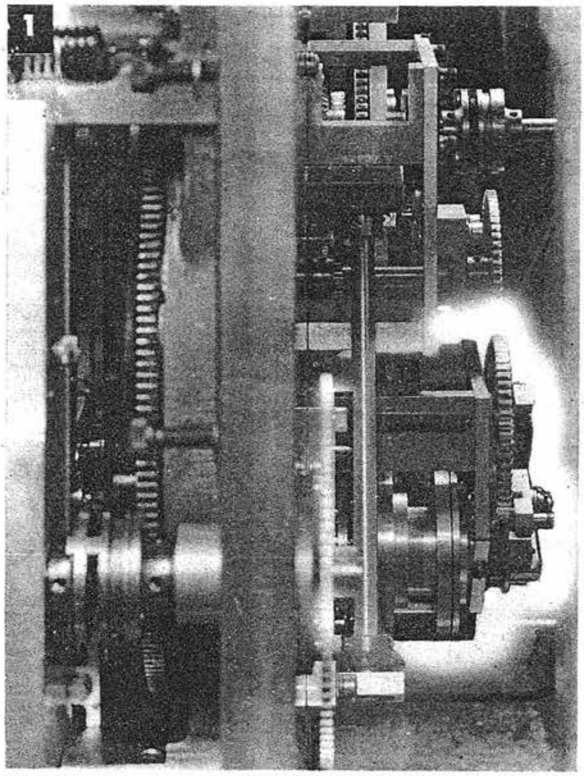
NOTE:
The $1/cR$ cam controls the travel of the $1/cR$ integrator. Position the $1/cR$ integrator carriage to make vernier clamp A-149 accessible before reinstalling the $1/cR$ cam. After reinstalling the cam, use clamp A-149 to adjust the integrator carriage roughly so that it does not limit the travel of the cam.

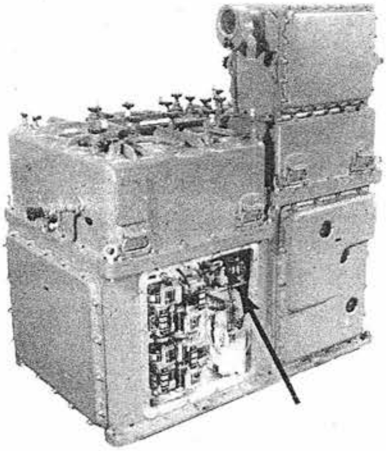
Reinstall the mechanisms removed.

Readjust clamps A-233, A-151, A-152, A-149, and A-179.

Run tests.

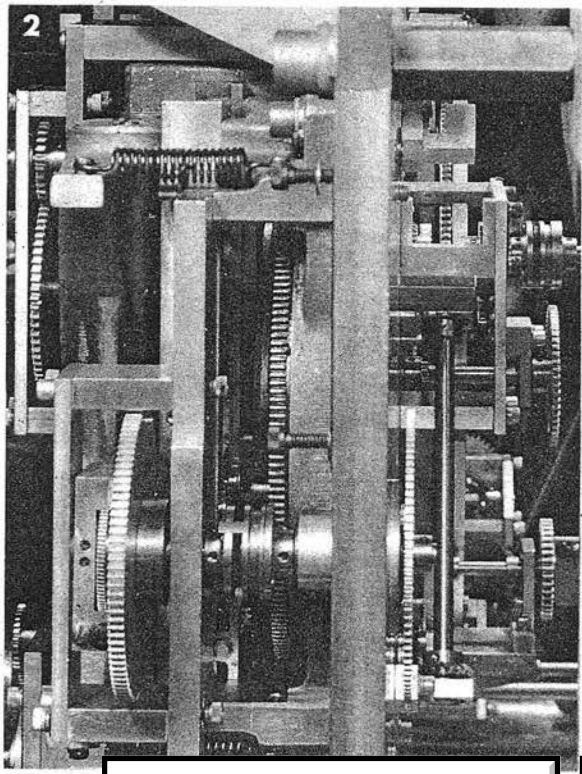
E INTERMITTENT DRIVE





Co Receiver and Mounting Plate, page 666
cR Vernier Assembly, page 676
cR Intermittent Drive, page 677
1/*cR* Cam, page 678

1 Back out the two screw dowels. Remove the three screws securing the intermittent drive. Support the mechanism while removing the last screw.



2 Remove the intermittent drive.

To reinstall the intermittent drive, reverse the removal procedure.

Tighten clamp A-251.

Reinstall the other mechanisms removed.

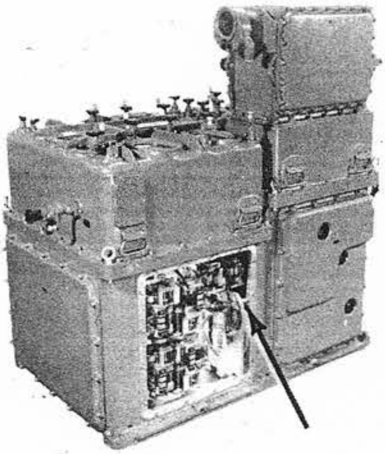
Readjust clamps A-250, A-233, A-151, A-152, A-149, A-150, A-145, A-146, and A-179.

Run tests.

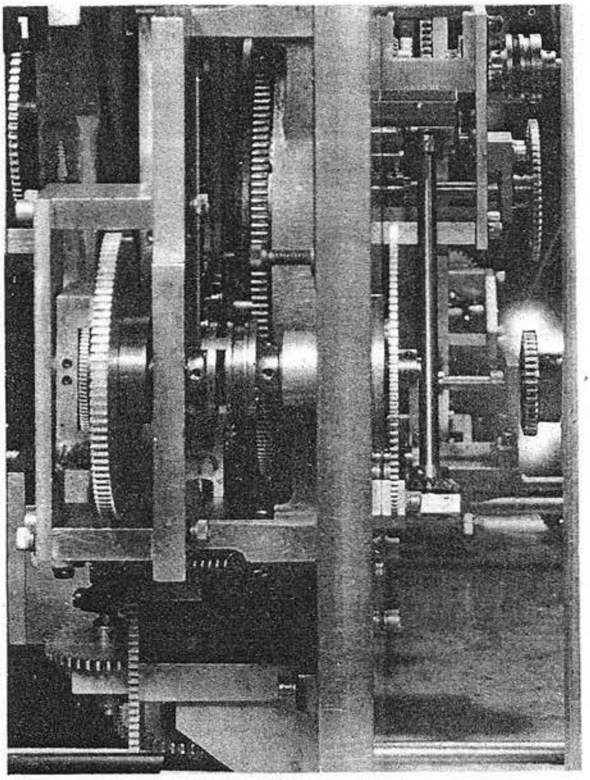
Gene Slover's US Navy Pages

Table of Contents

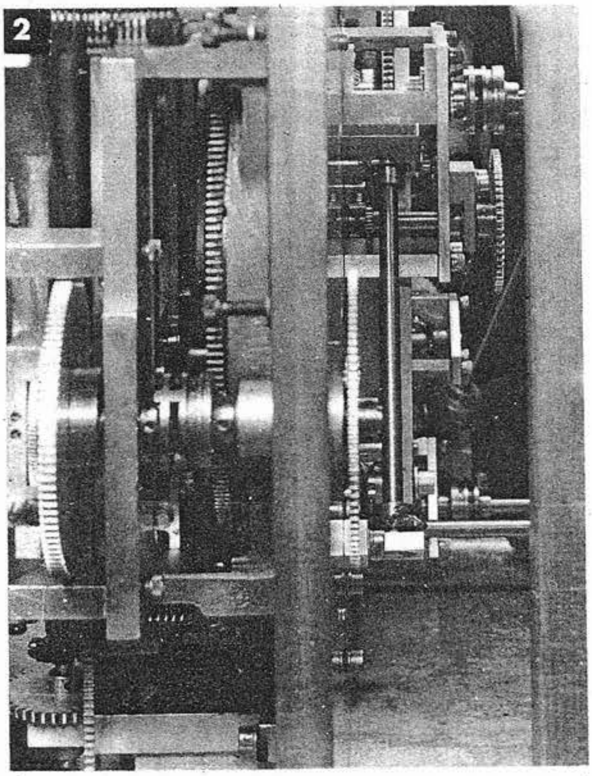
SECANT E VERNIER ASSEMBLY



Co Receiver and Mounting Plate, page 666
cR Intermittent Drive, page 677
1/*cR* Cam, page 678
E Intermittent Drive, page 680



1 Remove the two screws securing the cast hanger to the rear of the integrator mounting plate.

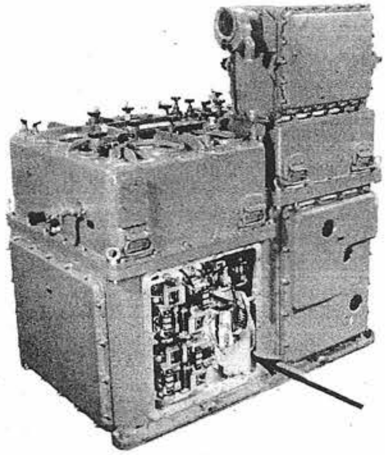


2 Lift out the vernier assembly.

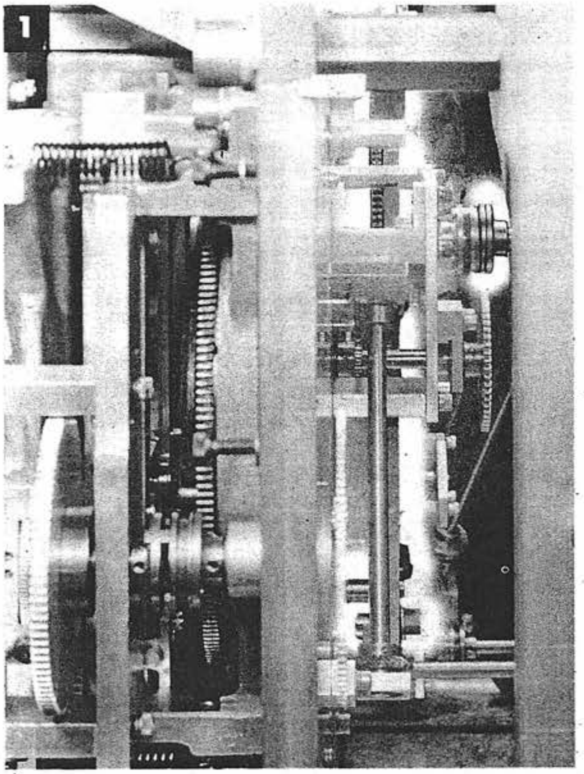
To reinstall the assembly, reverse the removal procedure.

Reinstall the other mechanisms removed, and follow the readjustment procedure outline for the reinstallation of the *E* intermittent drive, page 680

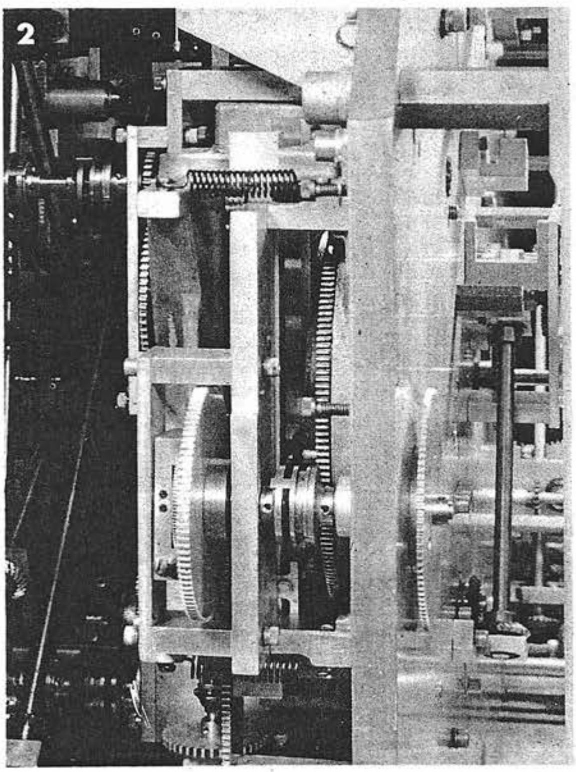
SECANT E CAM



Co Receiver and Mounting Plate, page 666
cR Vernier Assembly, page 676
cR Intermittent Drive, page 677
1/*cR* Cam, page 678
E Intermittent Drive, page 680
Secant *E* Vernier Assembly, page 681



1 Remove the coupling section from the *E* line between the front and back units of the computer.
Back out the two screw dowels and remove the three screws securing the secant *E* cam.



2 Remove the secant *E* cam.

To reinstall the secant *E* cam, reverse the removal procedure.

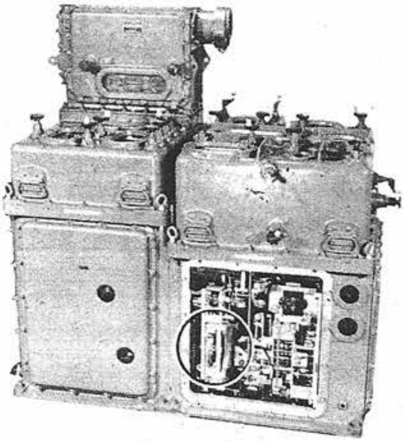
NOTE:
It is important to reinstall the cam so that its travel corresponds with the travel of the secant *E* integrator. The vernier of the integrator must be accessible.

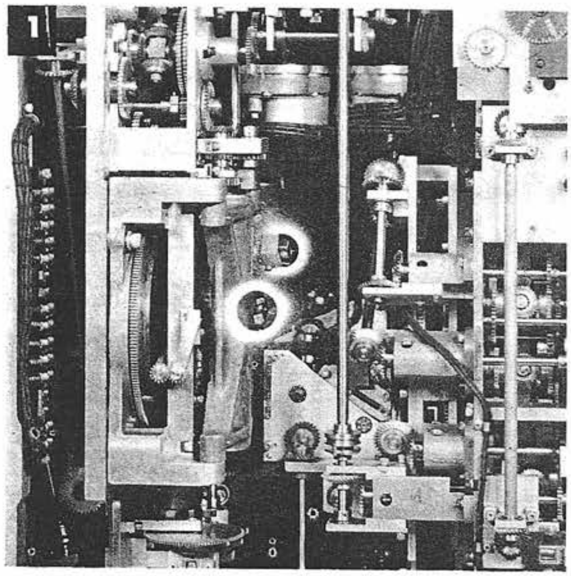
Reinstall the other mechanisms removed.

Readjust clamps A-250, A-251, A-233, A-151, A-152, A-149, A-150, A-145, A-146, A-147, A-148, A-179 and A-260.

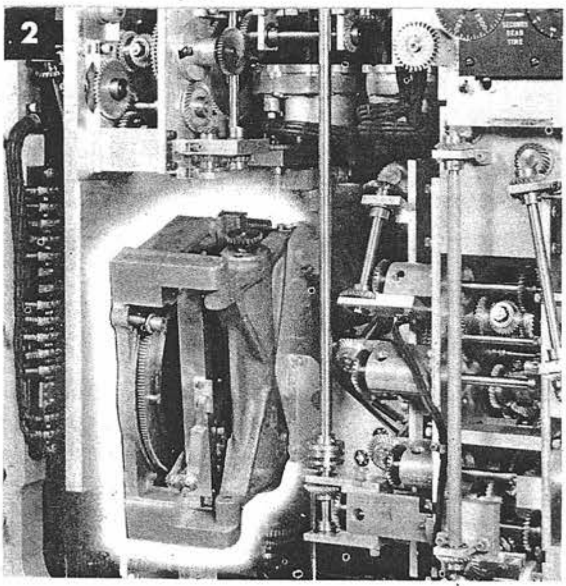
Run tests.

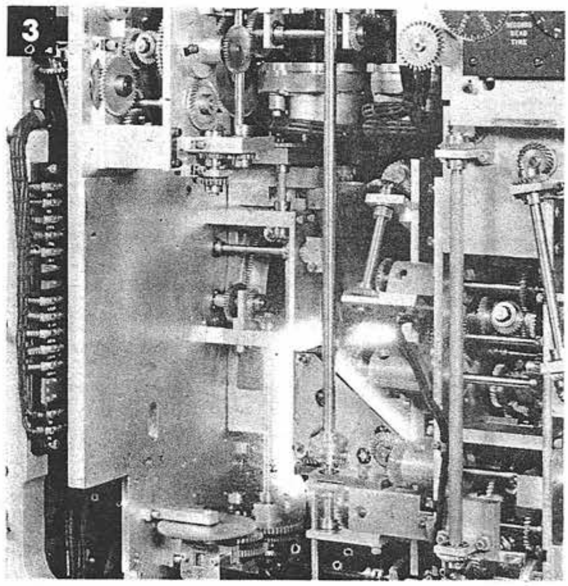
RdE INTEGRATOR





1 Loosen clamps A-211 and A-155. Slip the gear on which each clamp is mounted toward the end of its shaft as far as clearance will permit.





2 Remove the three screws securing the integrator to the mounting plate. Work the dowels free from the plate. Remove the integrator.

3 To provide clearance, it may be necessary to remove the $WrD + KRdBs$ follow-up, page 684.

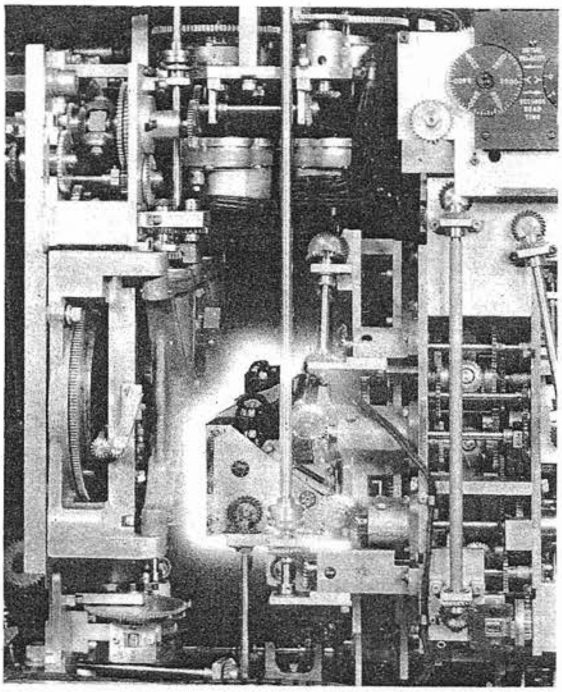
To reinstall the integrator, reverse the removal procedure.

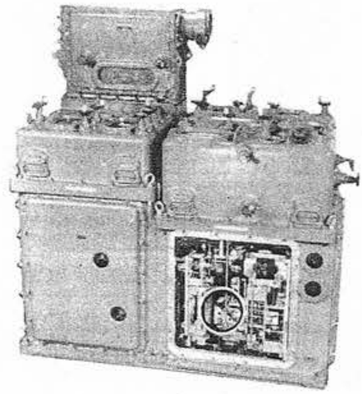
Tignten clamp A-211.

Readjust clamps A-155 and A-154.

Run tests.

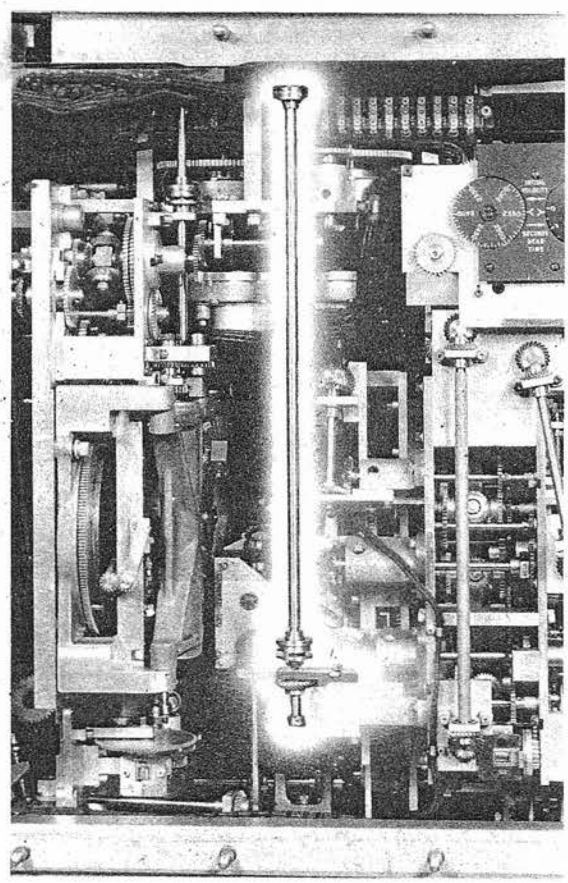
WrD + KRdBS FOLLOW-UP

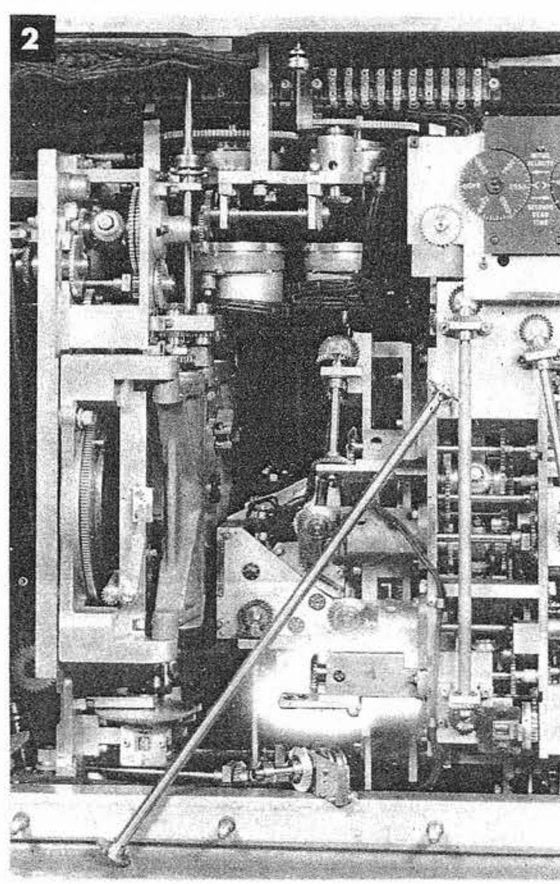




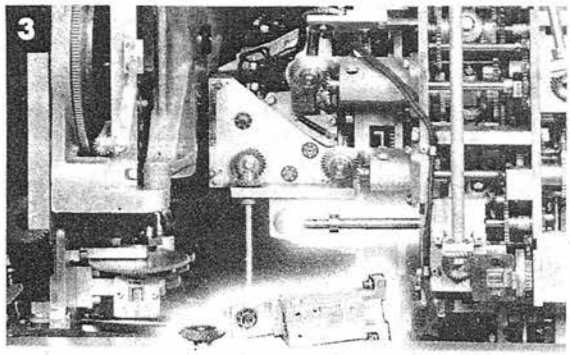
1 Remove the locking springs from the long coupling shaft in the *Xo* line near the follow-up. Remove the shaft.
Remove the two screws securing the mating shaft assembly below the coupling. Remove the shaft assembly.

2 Unpin the collar of the bevel gear that meshes with the gear on the shaft just removed. Remove the gear.





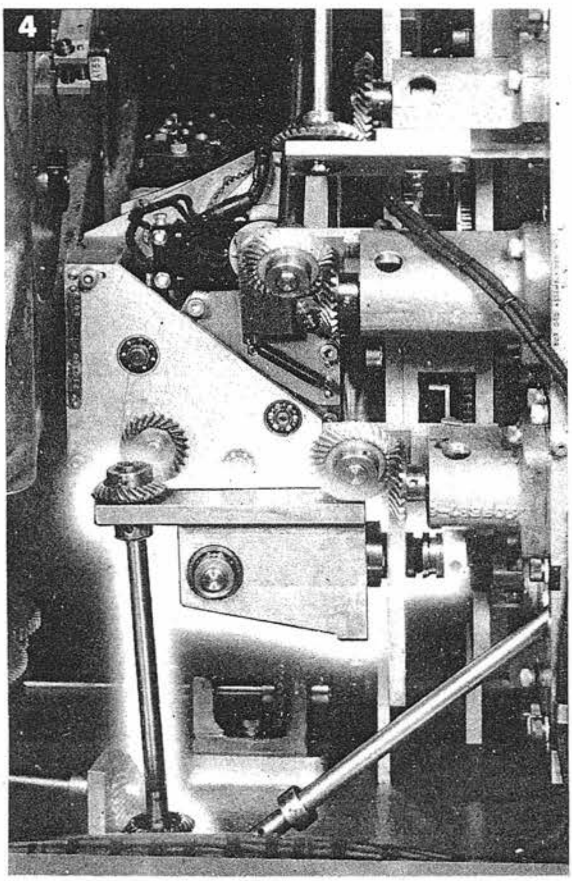
Gene Slover's US Navy Pages Table of Contents

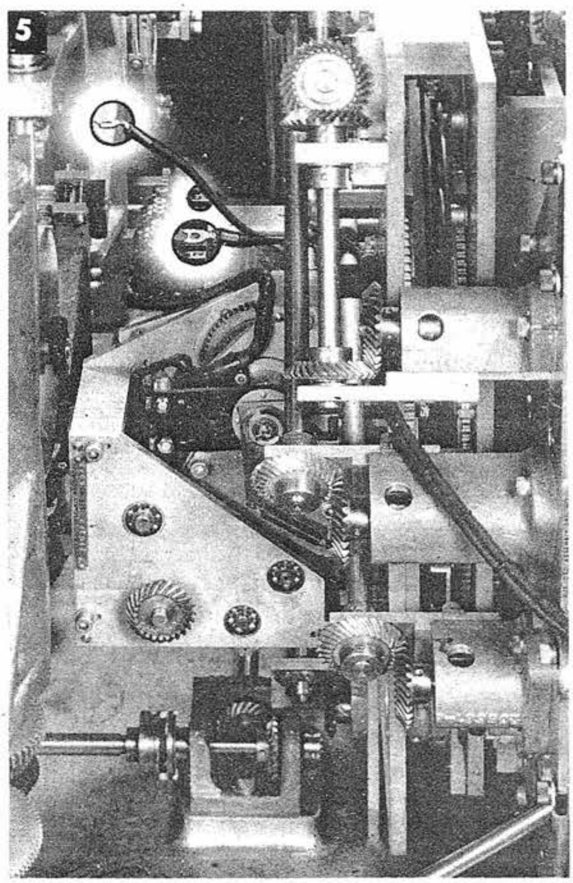


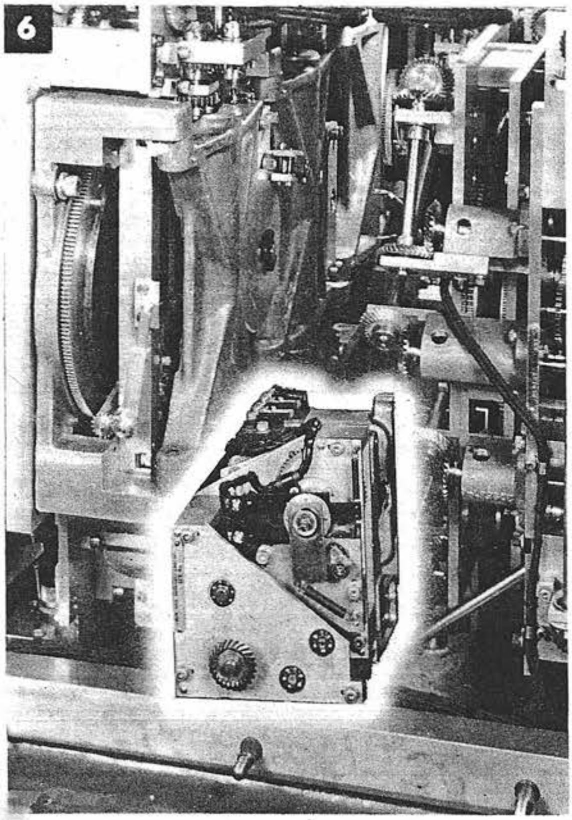
3 Remove the two screws securing the casting for the shaft assembly. Remove the casting so that the shaft hangs free.

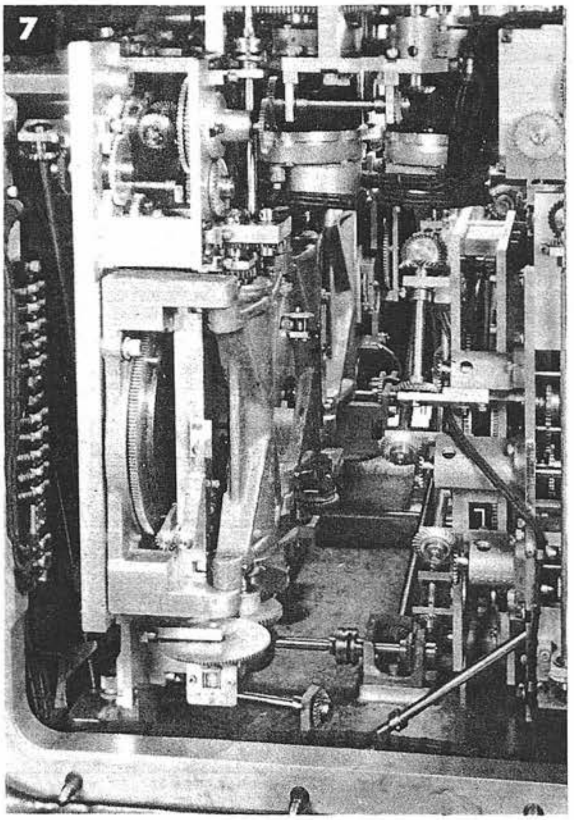
4 Remove the screws securing the hangers and casting for the input and output gearing of the follow-up. Remove the assembly. For clearance it may be necessary to loosen the screws in the terminal block on the floor of the computer.

5 Remove the two screws connecting cable leads 1G and GG to the servo terminal block of the $WrD + KRdBs$ follow-up.









6 Remove the four screws securing the servo motor. Support the follow-up while removing the last screw.

7 Remove the follow-up.

To reinstall the $WrD + KRdBs$ follow-up, reverse the removal procedure.

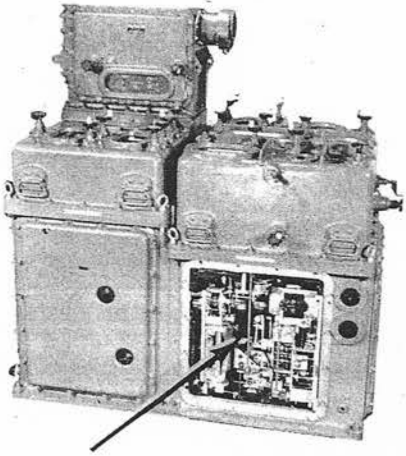
NOTE:
Tighten one screw to hold the follow-up at the proper mesh before inserting the other three screws.

Reinstall the Xo coupling shaft.

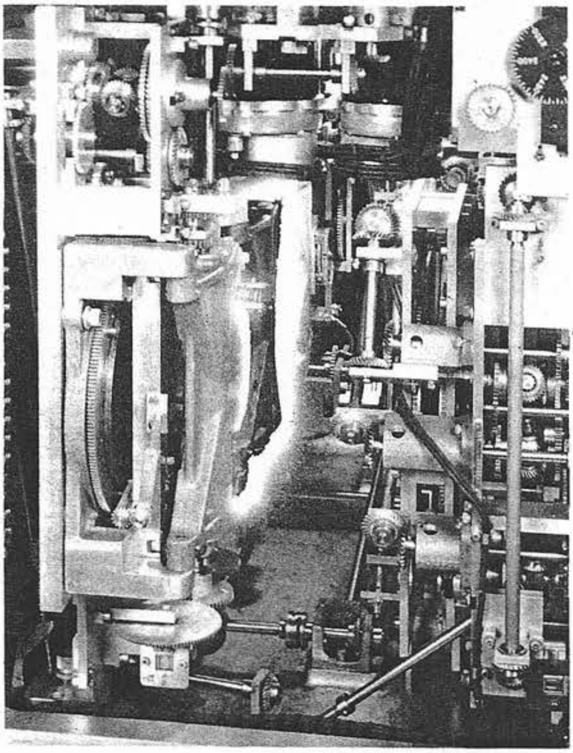
Readjust clamps A-131, A-229, and A-230.

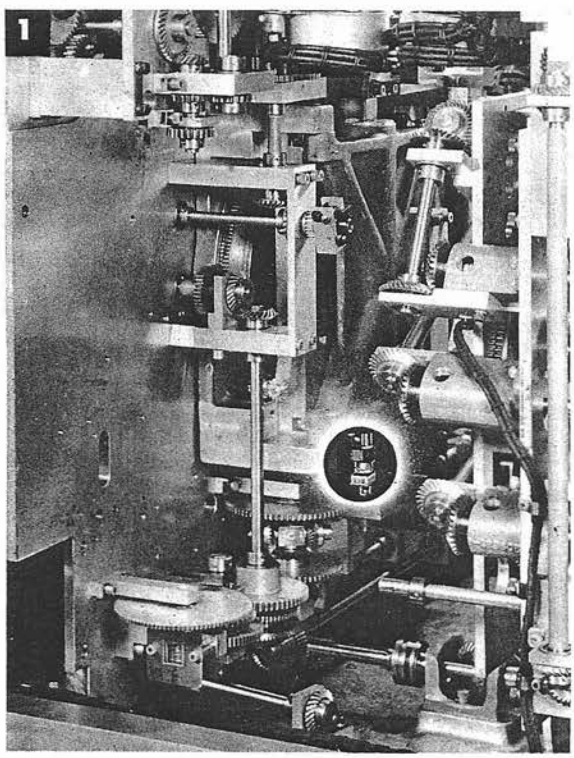
Run computer and star shell tests.

SECANT E INTEGRATOR



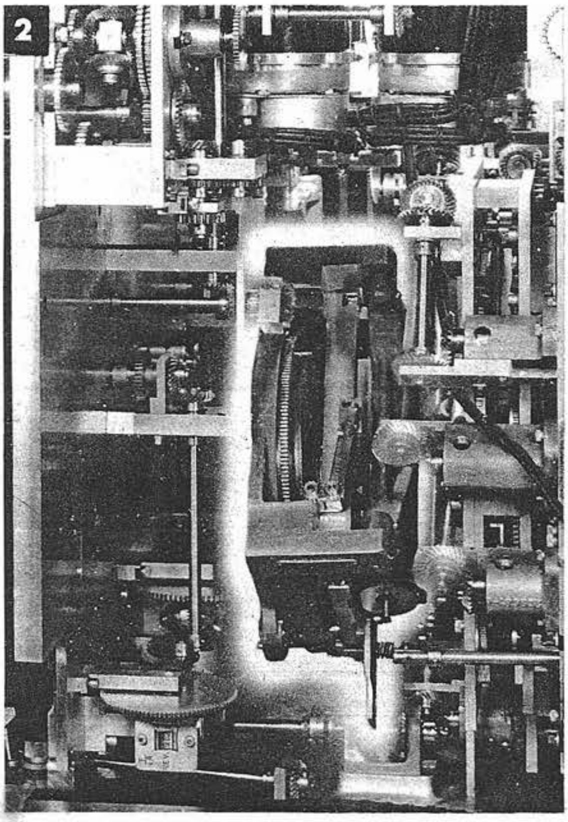
RdE Integrator, page 683
WrD + *KRdBs* Follow-up, page 684



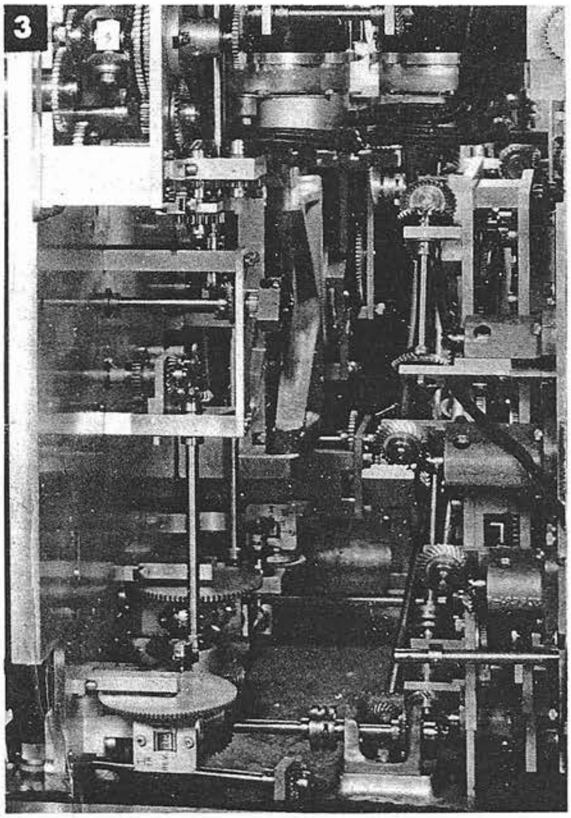


1 Loosen clamps A-176 and A-143. Slide the coupling down out of the way. Be careful not to lose the upper spacer.

Remove the three screws securing the integrator.



2 Work the dowels free from the mounting plate. Tilt the integrator to clear.



3 Remove the integrator.

To reinstall the secant *E* integrator, reverse the removal procedure. The travel of the integrator must agree with the travel of the secant *E* cam. The vernier adjustment must be accessible.

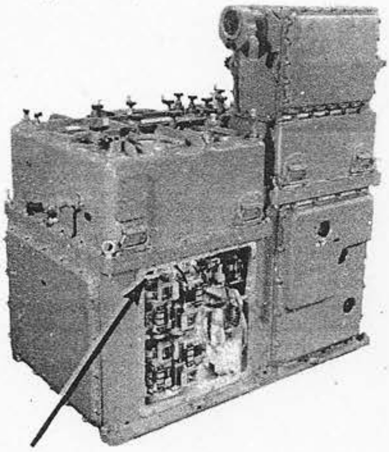
Reinstall the other mechanisms removed.

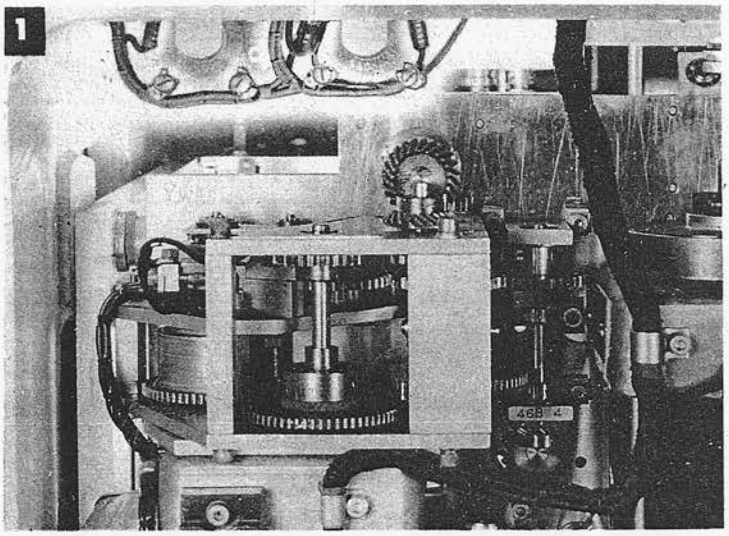
Tighten clamps A-176, A-143, and A-211.

Readjust clamps A-147, A-148, A-154, A-155, A-131, A-229, and A-230.

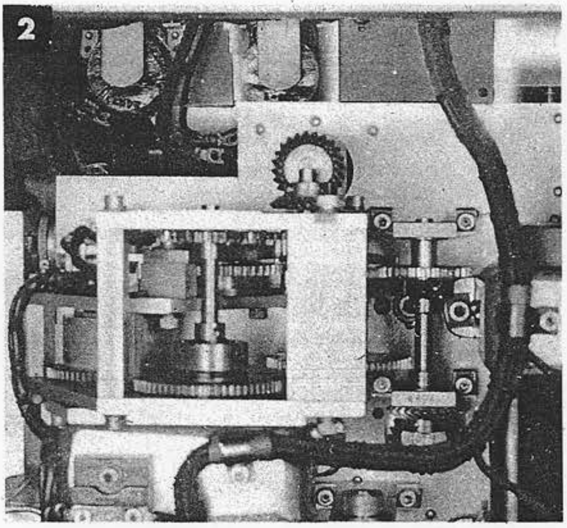
Run tests.

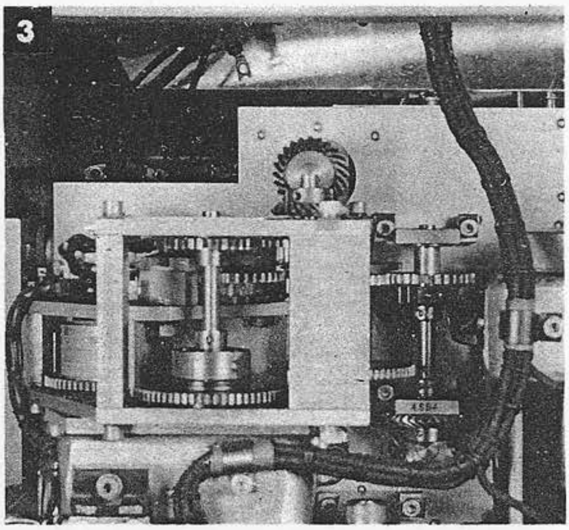
TARGET COURSE INCREASING AND DECREASING RELAYS





1 Remove the screws from all cable connections on the relays. Do not drop the terminal screws. They cannot be picked up with a magnet.



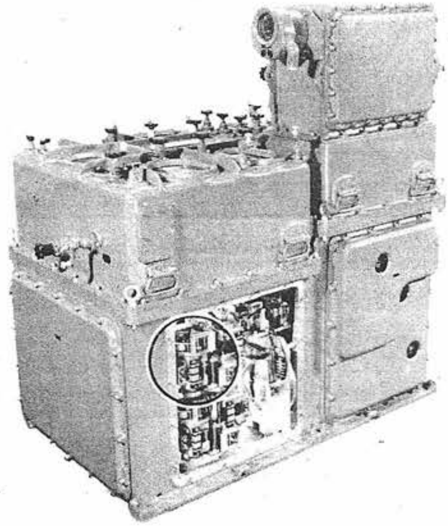


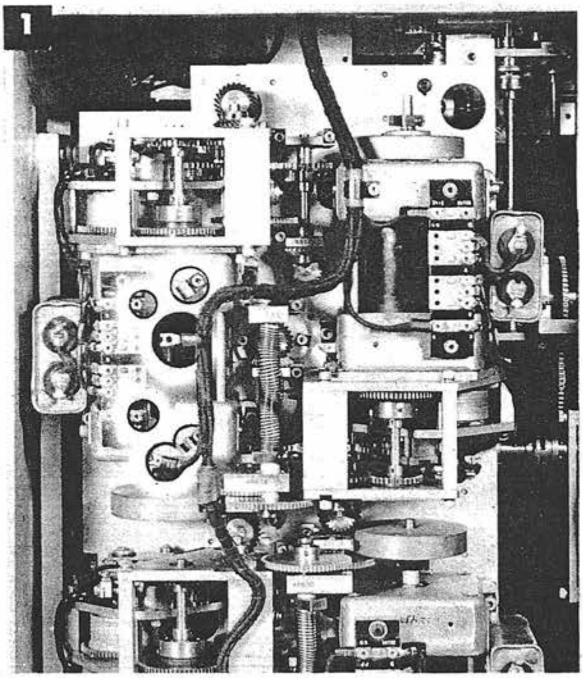
2 Remove the two screws securing the relay mounting plate.

3 Remove the relays.

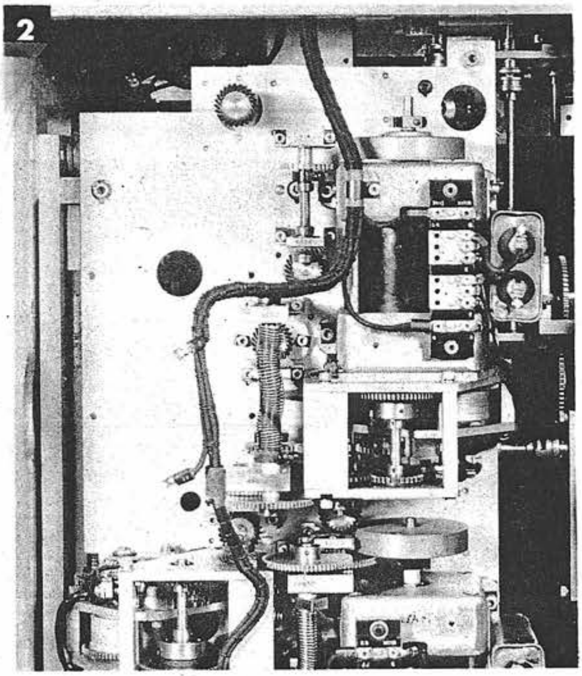
To reinstall the relays, reverse the removal procedure.

Ywgr FOLLOW-UP





1 Remove the two screws connecting cable leads F and FF to the servo terminal block.
Loosen the two screws securing the cable clamps to the servo motor.
Free the cable.



2 Remove the four screws securing the servo motor to the mounting plate.
Support the follow-up while removing the last screw.
Remove the follow-up.

To reinstall the *Ywgr* follow-up, reverse the removal procedure.

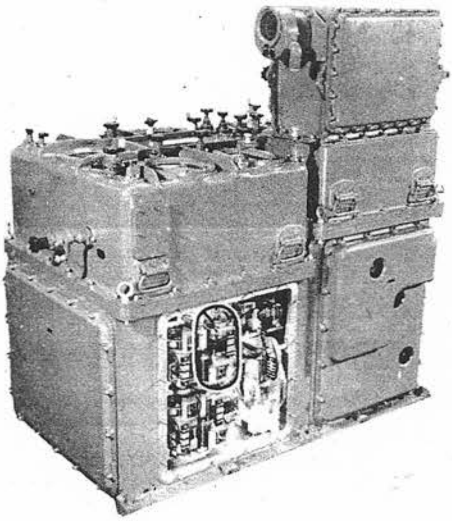
Readjust clamp A-101.

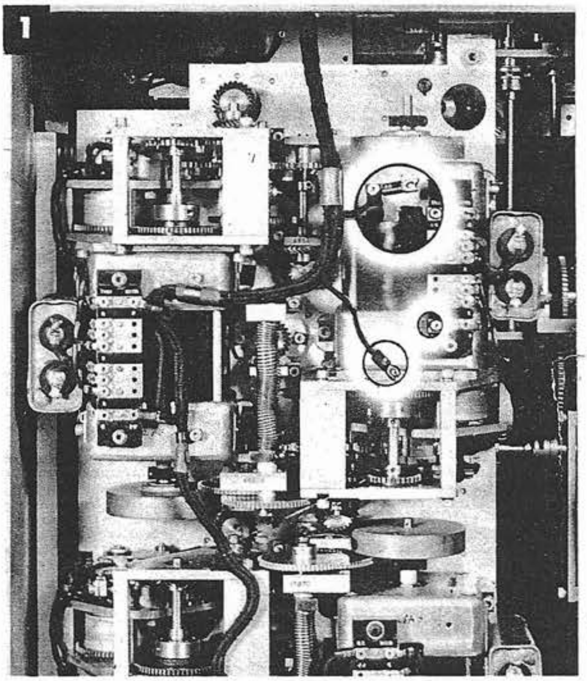
Check clamp A-100.

Run tests.

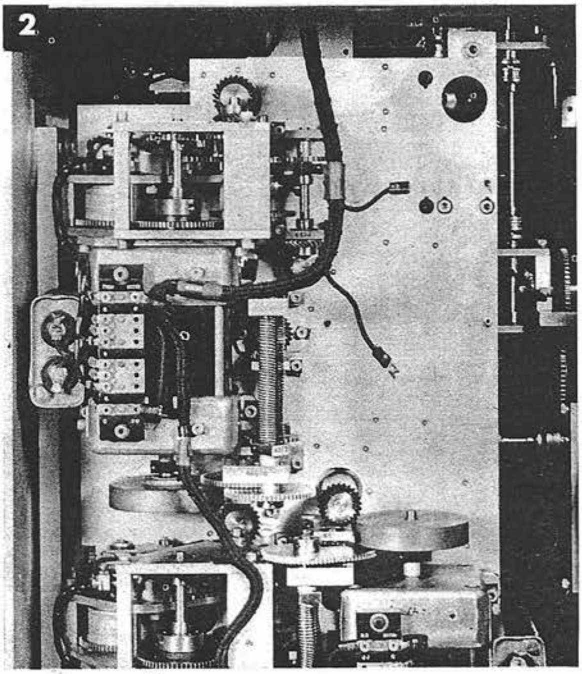
Gene Slover's US Navy Pages | Table of Contents

Dtwj FOLLOW-UP





1 Remove the two screws connecting cable leads G and GG to the servo terminal block.
Loosen the screw securing the cable clamp to the servo motor. Free the cable.



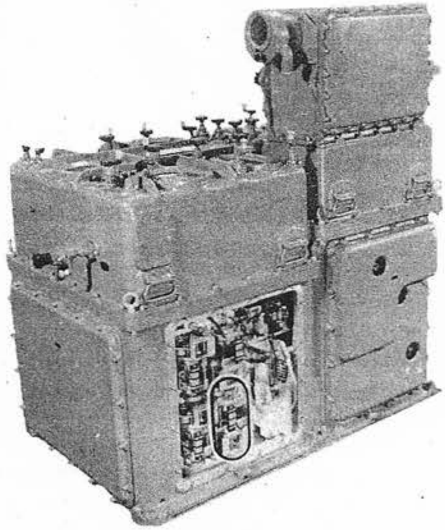
2 Remove the four screws securing the servo motor to the mounting plate. Remove the follow-up.

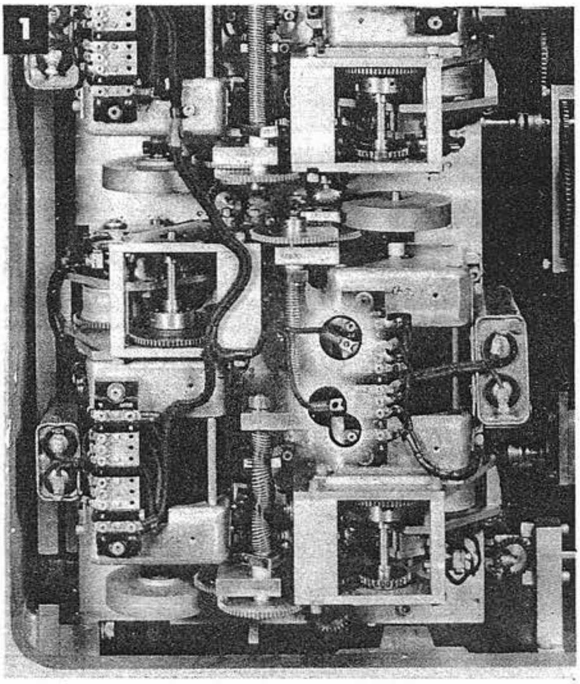
To reinstall the *Dtwj* follow-up, reverse the removal procedure.

Readjust clamps A-217 and A-102.

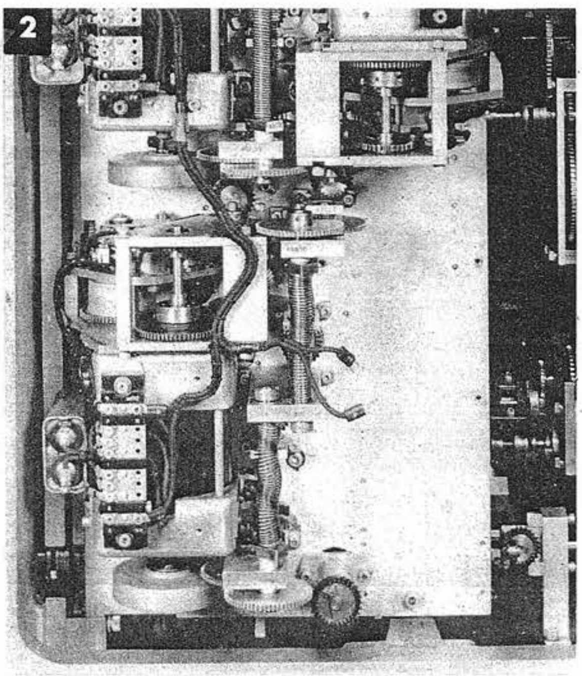
Run tests.

R2 FOLLOW-UP





1 Remove the two screws connecting cable leads J and JJ to the servo terminal block.



2 Remove the four screws securing the servo motor to the mounting plate. Support the follow-up while removing the last screw.
Remove the follow-up.

To reinstall the *R2* follow-up, reverse the removal procedure.

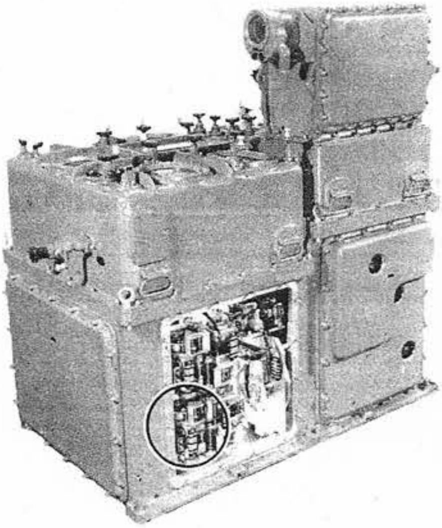
Readjust clamps A-220 and A-104.

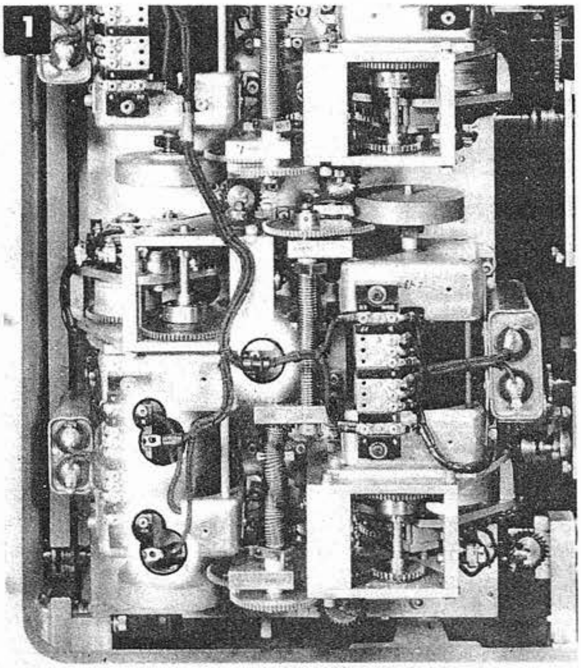
Run tests.

Gene Slover's US Navy Pages

Table of Contents

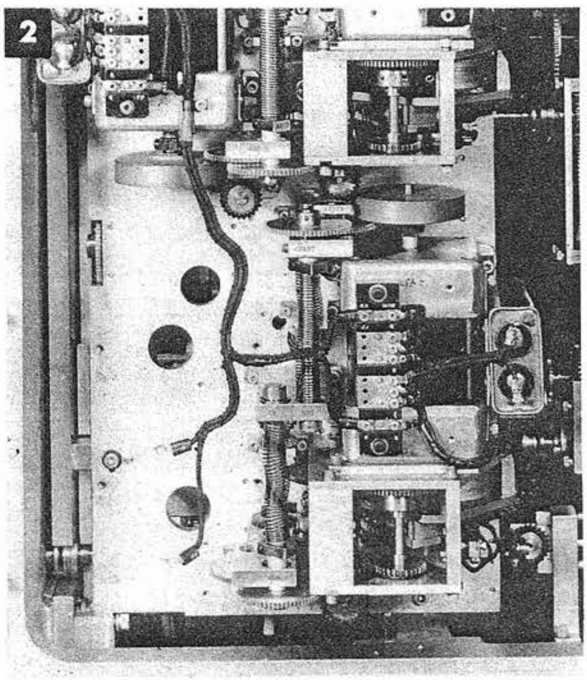
V FOLLOW-UP





1 Remove the two screws connecting cable leads H and HH to the servo terminal block.
Loosen the screw securing the cable clamp to the lower end of the follow-up gearing. Free the cable.

2 Remove the four screws securing the servo motor to the mounting plate. Support the follow-up while removing the last screw.
Remove the follow-up.

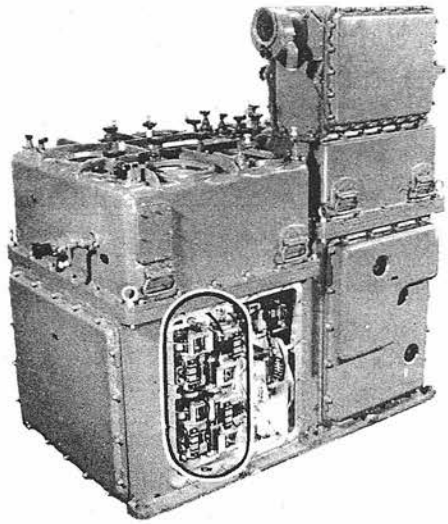


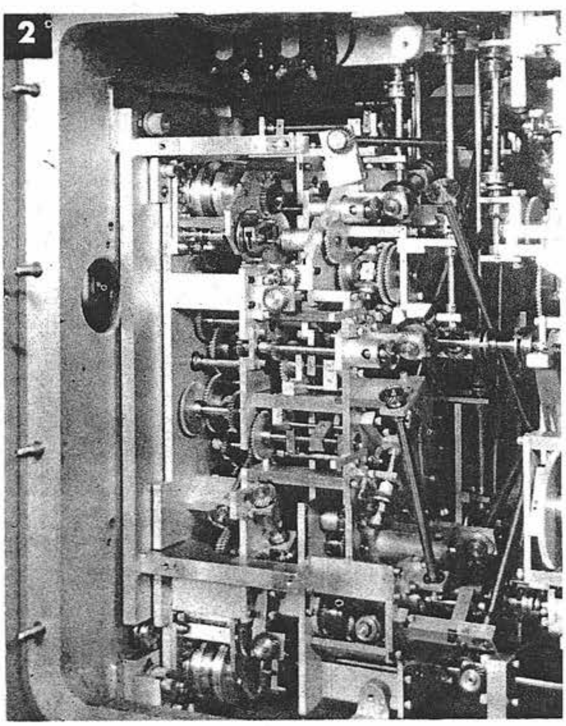
To reinstall the *V* follow-up, reverse the removal procedure.

Readjust clamps A-221 and A-103.

Run tests.

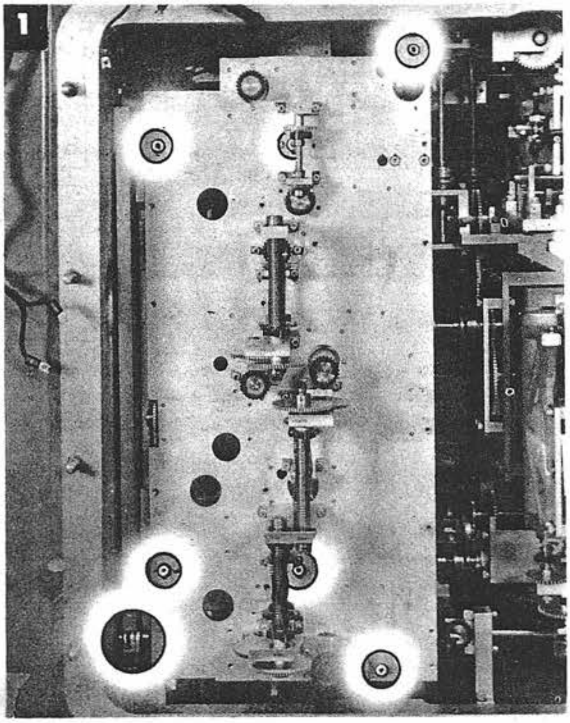
PREDICTION FOLLOW-UP MOUNTING PLATE



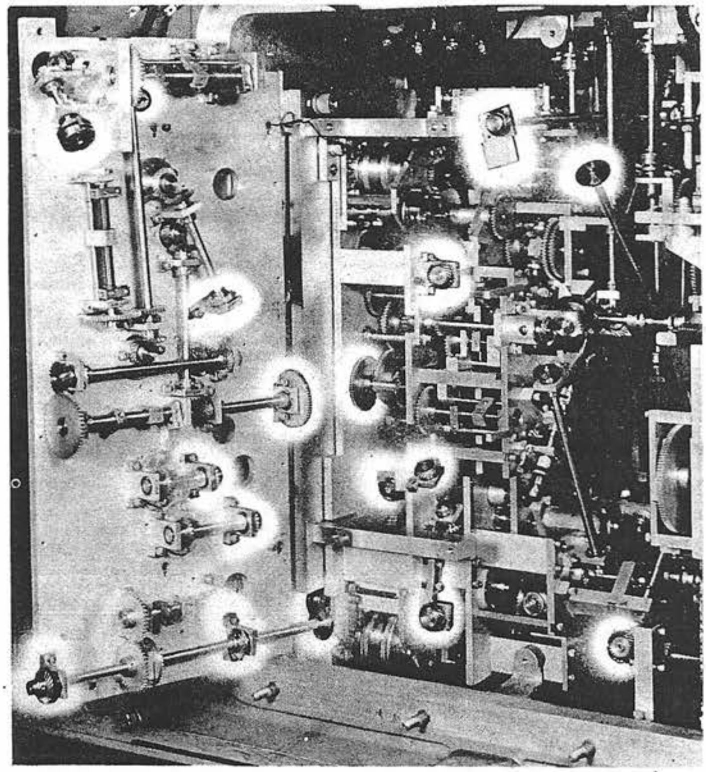


Ywgr Follow-up, page 690
Dtwj Follow-up, page 691
R2 Follow-up, page 692
V Follow-up, page 693

1 Lay the cable to one side.
Remove the two screws securing the hanger on the *Dtwj* output gearing to the hanger behind the upper right corner of the plate.
Remove the six large screws securing the plate.
Tilt the right edge of the plate to disengage a coupling at the lower left corner.



2 Remove the plate.



To reinstall the plate, reverse the removal procedure. When positioning the plate, each connection indicated must be properly engaged before the screws are tightened.

Connect the power leads to the terminal blocks of the follow-ups in the order indicated in the following steps.

Loosen clamps A-100 and A-156 before attempting any readjustment.

Readjust clamps A-184, A-180, A-198, and A-74.

Connect power leads F and FF to the terminal block of the *Ywgr* servo motor. Readjust clamps A-101 and A-100.

Connect power leads J and JJ to the terminal block of the *R2* servo motor. Readjust clamps A-220, A-104 and A-156.

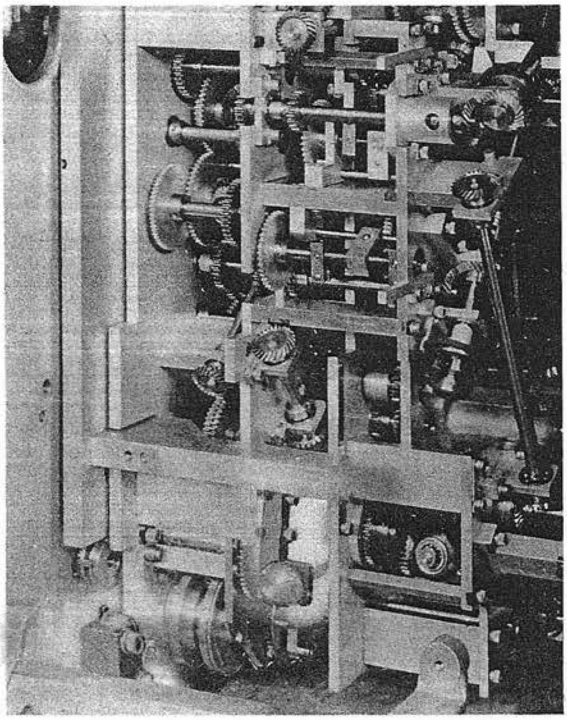
Connect power leads H and HH to the terminal block of the *V* servo motor. Readjust clamps A-221 and A-103.

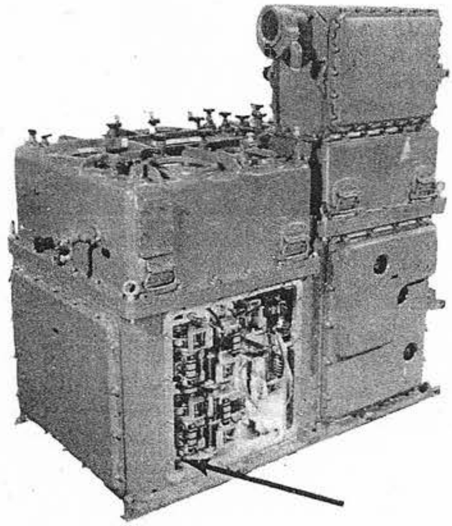
Connect power leads G and GG to the terminal block of the *Dtwj* servo motor. Readjust clamps A-217 and A-102.

Recheck the adjustment of clamps A-100 and A-106.

Check clamps A-110, A-107, A-105, and A-157.

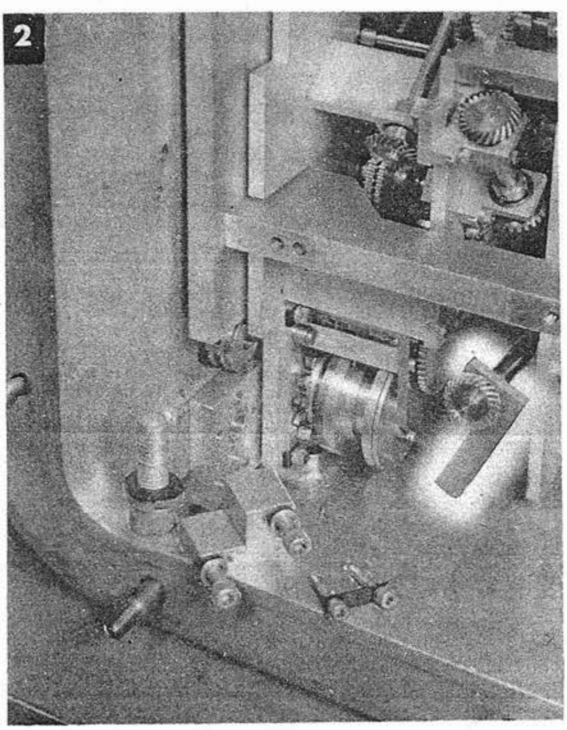
E2 INTERMITTENT DRIVE



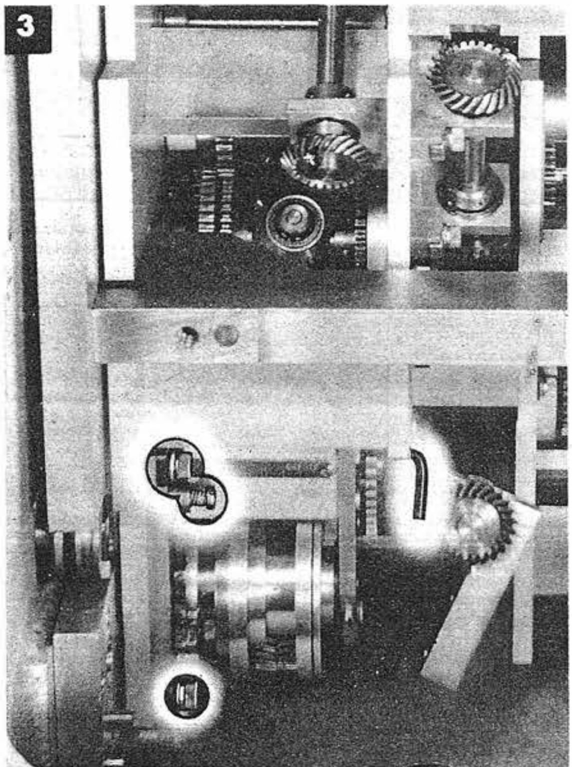


Ywgr Follow-up, page 690
Dtwj Follow-up, page 691
R2 Follow-up, page 692
V Follow-up, page 693
Prediction Follow-up Mounting Plate, page 694

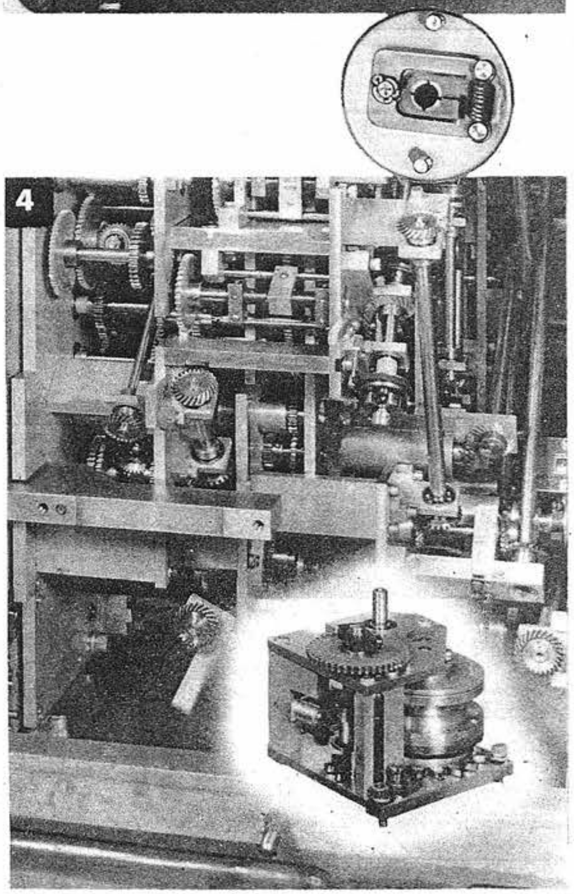
1 Remove the two screws securing the block at the lower front corner of the computer.
Remove the block.
Remove the large screw securing the large mounting plate to the computer.
Remove the two screws securing the hanger just behind the intermittent drive.



2 Let the hanger swing free.



3 Loosen the shock absorber clamp. Remove the shock absorber. Using a socket head screw wrench, remove the rear screw of the intermittent drive.
Back out the two screw dowels and remove the other two screws.



4 Remove the intermittent drive.

To reinstall the intermittent drive, reverse the removal procedure.

Tighten clamps A-114 and A-182. (CAUTION: These clamps cannot be reached after the follow-up plate is installed.)

Reinstall the follow-up mounting plate and the *Ywgr*, *Dtwj*, *R2*, and *V* follow-ups.

Readjust clamp A-72 and make the adjustments listed in the reinstallation of the follow-up mounting plate, page 695

Run tests.

This is Volume Two Part 2 with pages from 698 to 871. Click on page/subject to go to that page. Click in red blocks to download those pages from the main page

CONTENTS

VOLUME ONE

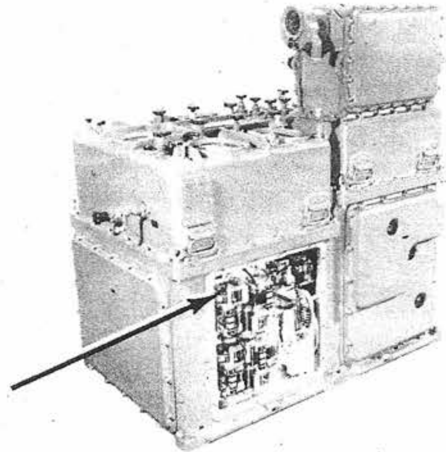
For Volume One click here to return to main download page

VOLUME TWO

click here to return to main download page for these pages

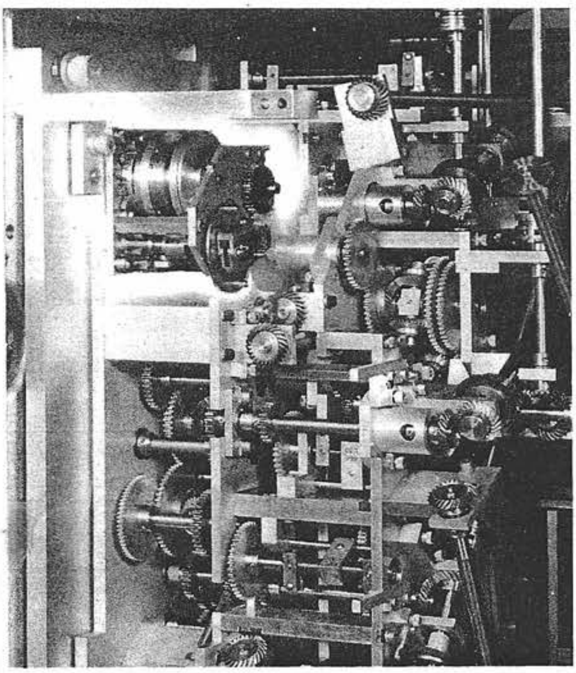
Note: pages 815-830 and 862 are missing and will be posted ASAP

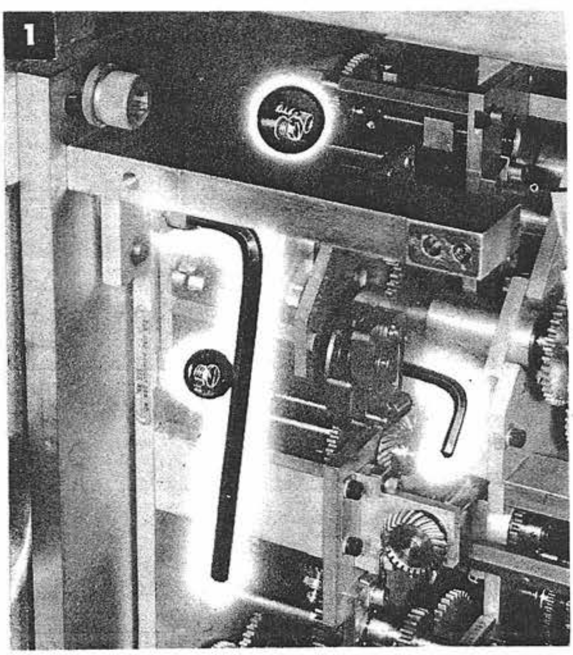
dRs INTERMITTENT DRIVE



Prediction Follow-up Mounting Plate, page 694

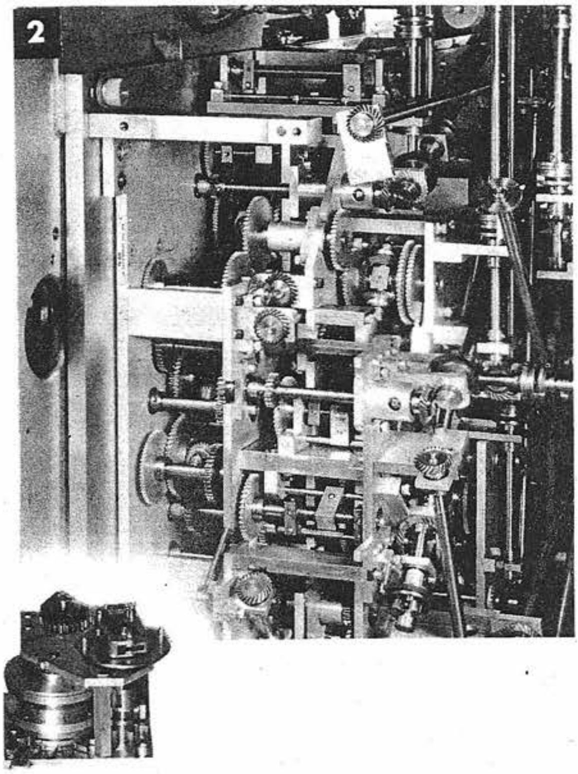
NOTE:
The *dRs* intermittent drive can be removed without removing the follow-up mounting plate if the *Co* receiver is removed.





1 Remove the large screw securing the intermittent drive plate.

Back out the two screw dowels and remove the three screws securing the intermittent drive.



2 Tilt the intermittent drive to clear the surrounding gearing and remove it.

To reinstall the *dRs* intermittent drive, reverse the removal procedure.

Reinstall the *Co* receiver.

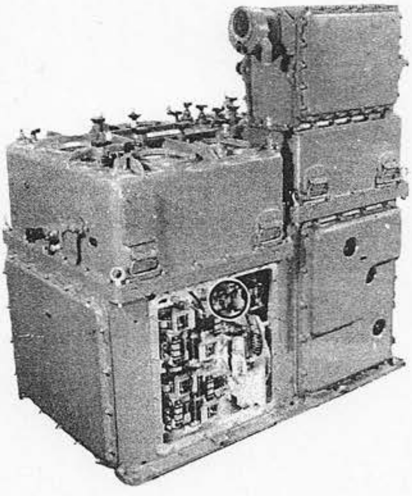
Readjust clamps A-181 and A-179.

Run tests.

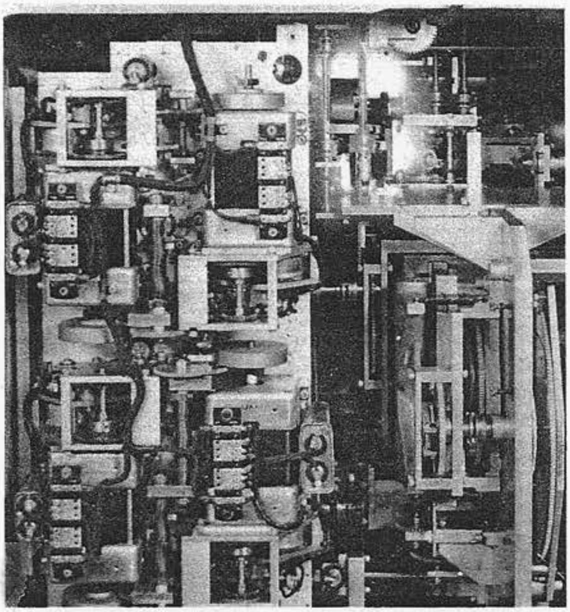
If the prediction follow-up mounting plate has been removed, reinstall it.

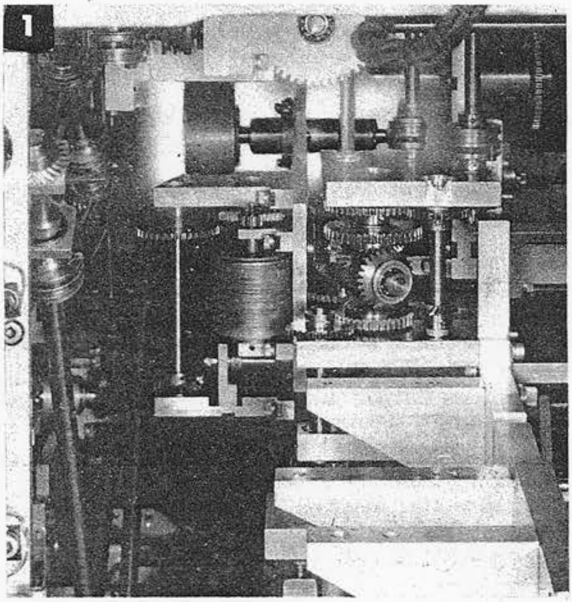
Readjust clamp A-181. Make readjustments listed in the reinstallation of the plate, page 695.

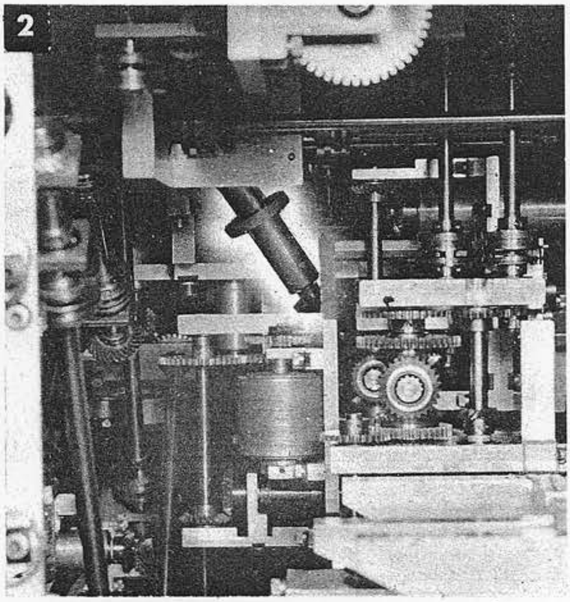
BEARING FILTER ASSEMBLY



Co Receiver, page 666



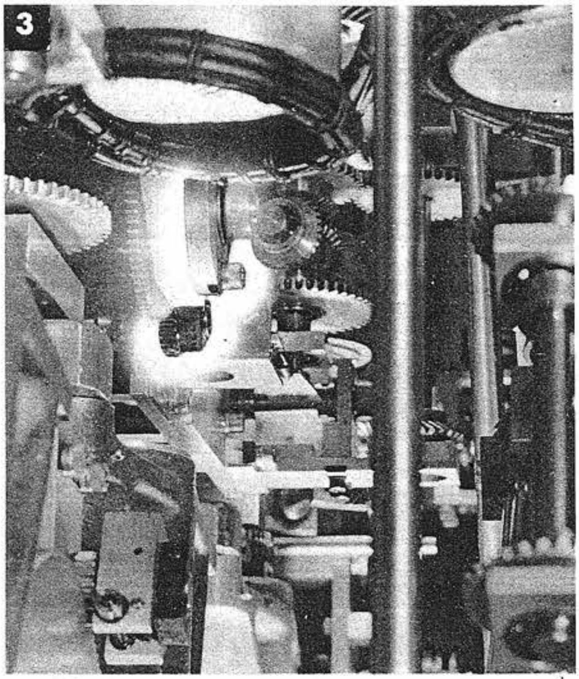




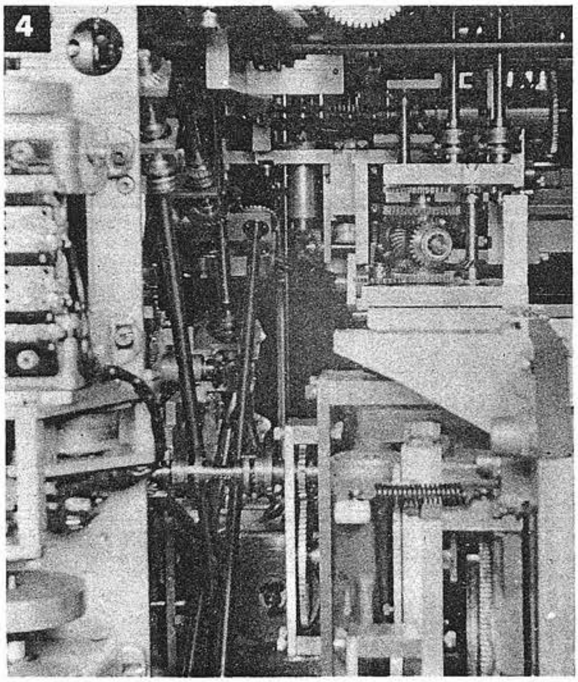
1 Loosen clamp A-209.
Remove the two screws securing the adapter for the large damper shaft.

2 Tilt the assembly.
Remove the damper and then the shaft.

3 From the opposite side of the computer, remove clamp A-225 and the gear on which it is mounted.
Remove the two screws securing the adapter above the gear just removed.
Turn the flat side of the adapter toward the bearing filter.
Working from both sides of the computer, remove the screws securing the bearing filter to its mounting brackets.
Slide the entire assembly forward to clear the end of the shaft from which clamp A-225 was removed.



4 Remove the assembly from the *Co* side of the instrument.



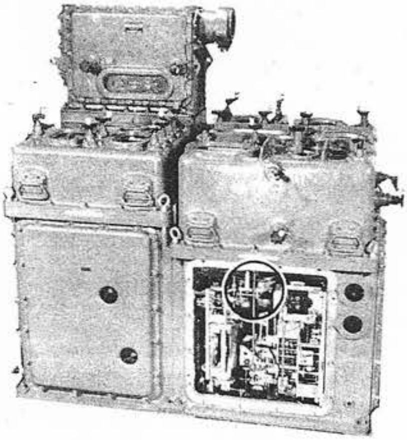
To reinstall the bearing filter assembly, reverse the removal procedure.

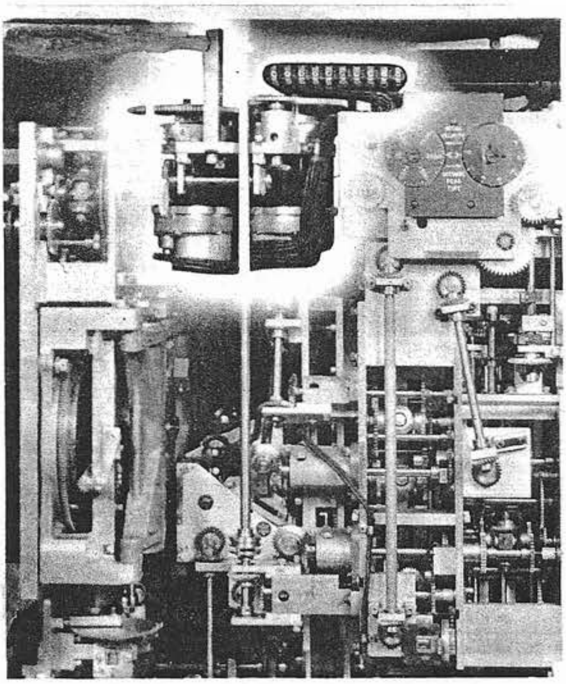
Reinstall the *Co* receiver.

Tighten clamps A-225 and A-209.

Readjust clamp A-179.

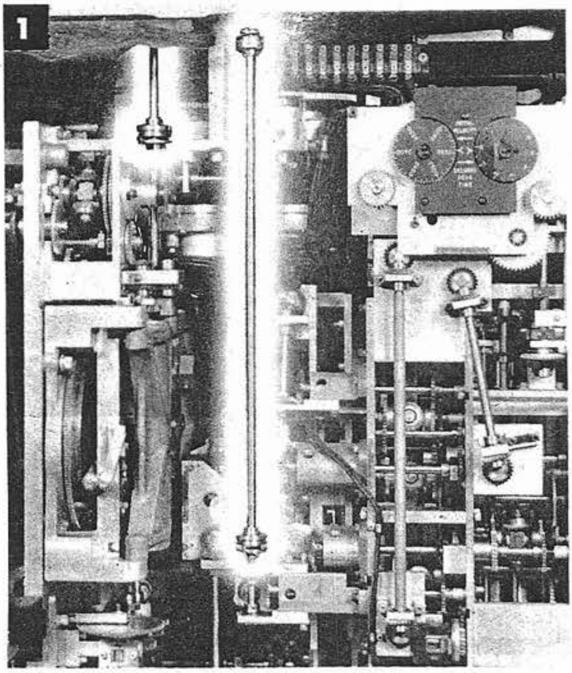
△cB′r and △cEb INDICATING TRANSMITTERS

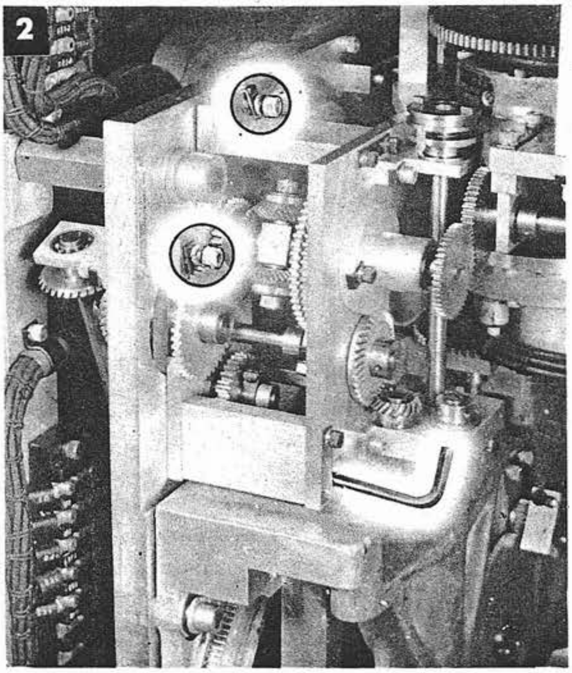


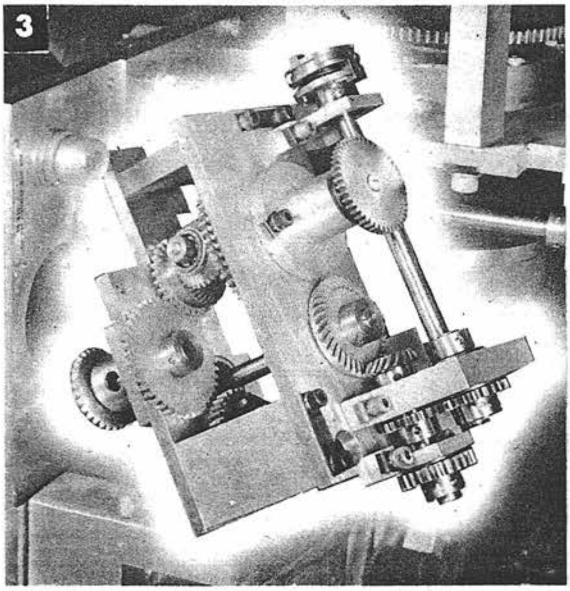


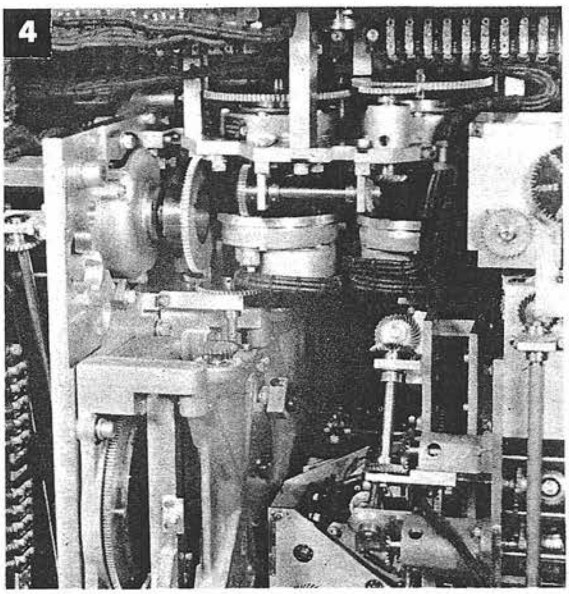
1 Remove the locking springs on the *Xo* coupling shaft, and on the shorter △*cEb* coupling shaft above the transmitter plate. Remove both shafts.

2 Remove the three screws securing the small gearing group to the upper corner of the integrator mounting plate.





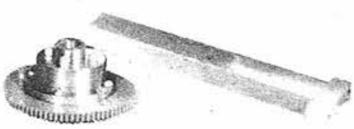


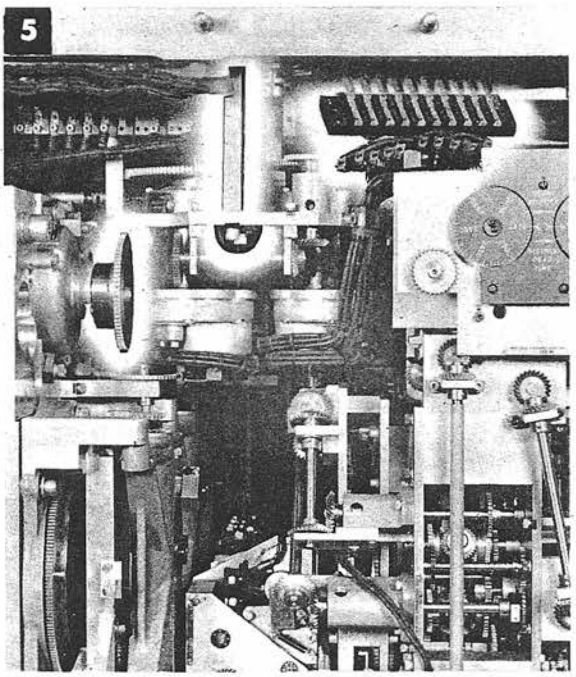


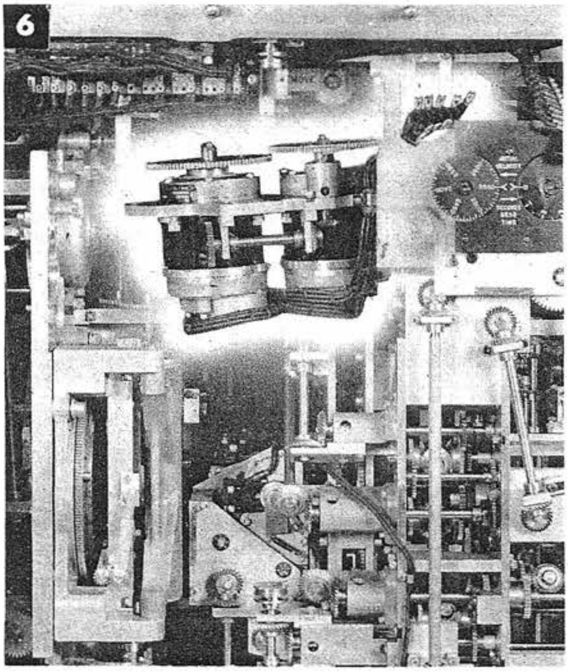
3 Tilt the gearing group to clear the adjacent mechanisms.

4 Remove the gearing group.

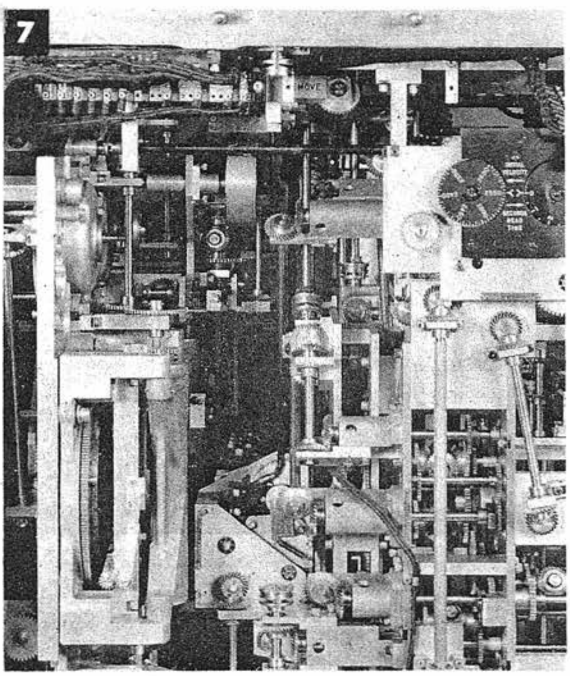
5 Using an offset fillister screw driver, loosen the locking nut on the rotor gear of the $\triangle cEb$ automatic transmitter. Remove the nut and the gear.
Remove all the screws connecting the transmitter cable leads to the terminal block.
Remove the two screws securing the terminal block.
Remove the four screws securing the front mounting bracket.
Remove the bracket.







6 Remove the screws securing the transmitter mounting plate to brackets on the other three sides of the mechanism. Support the mechanism while removing the last screw.



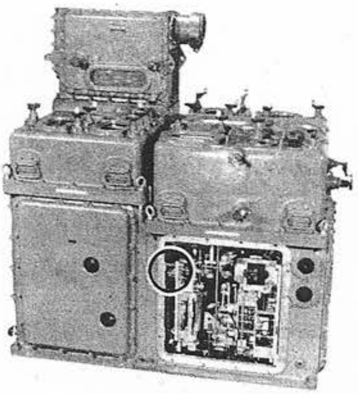
7 Turn the mechanism to clear the gearing and remove it.

To reinstall the transmitter mechanism, reverse the removal procedure.

When reinstalling the *Xo* shaft, turn the couplings to establish the proper relationship between the two connections, or readjust clamp A-131.

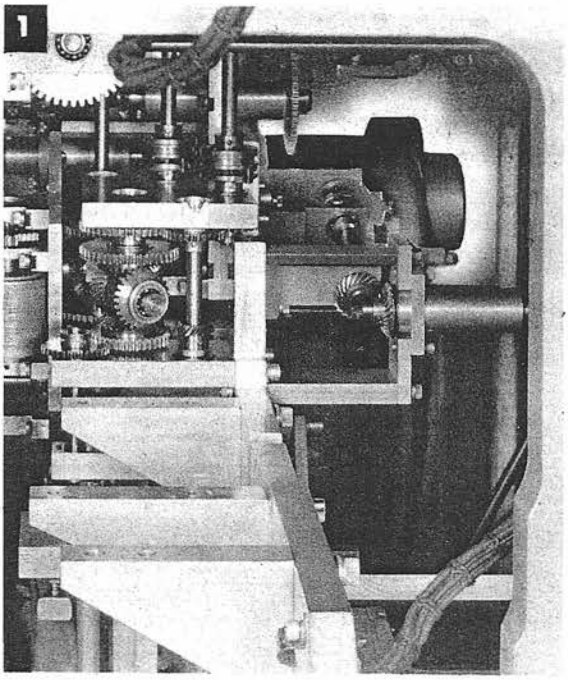
Run tests.

$\triangle cB'r$ and $\triangle cEb$ AUTOMATIC TRANSMITTERS

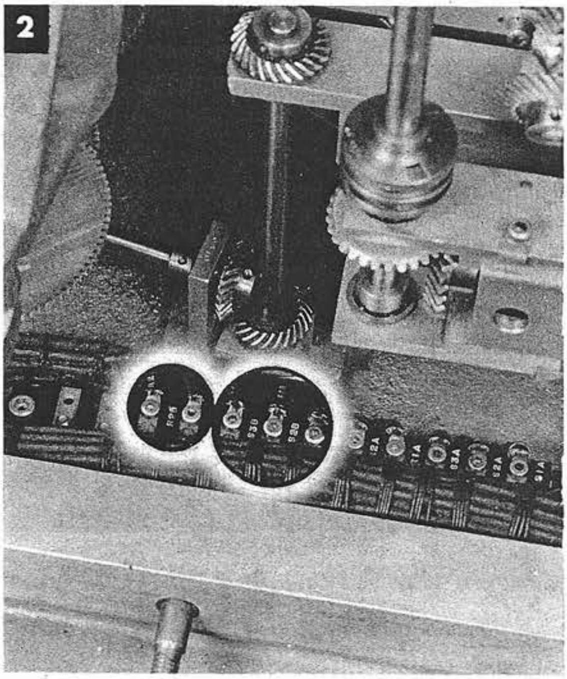


Co Receiver and Mounting Plate, page 666

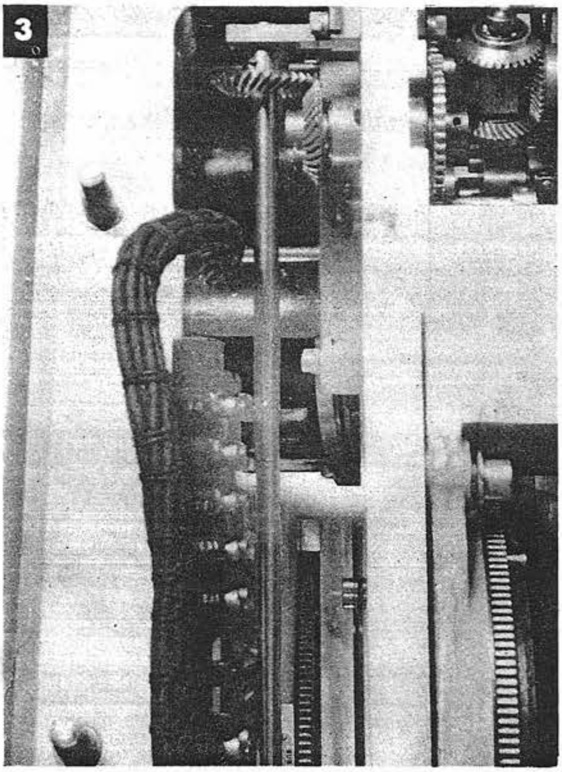
$\triangle cB'r$ AUTOMATIC TRANSMITTER



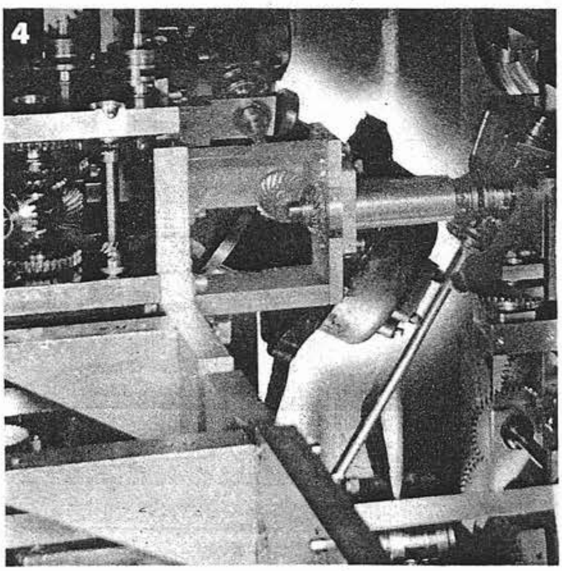
1 The $\triangle cB'r$ transmitter, seen from the *Co* side.



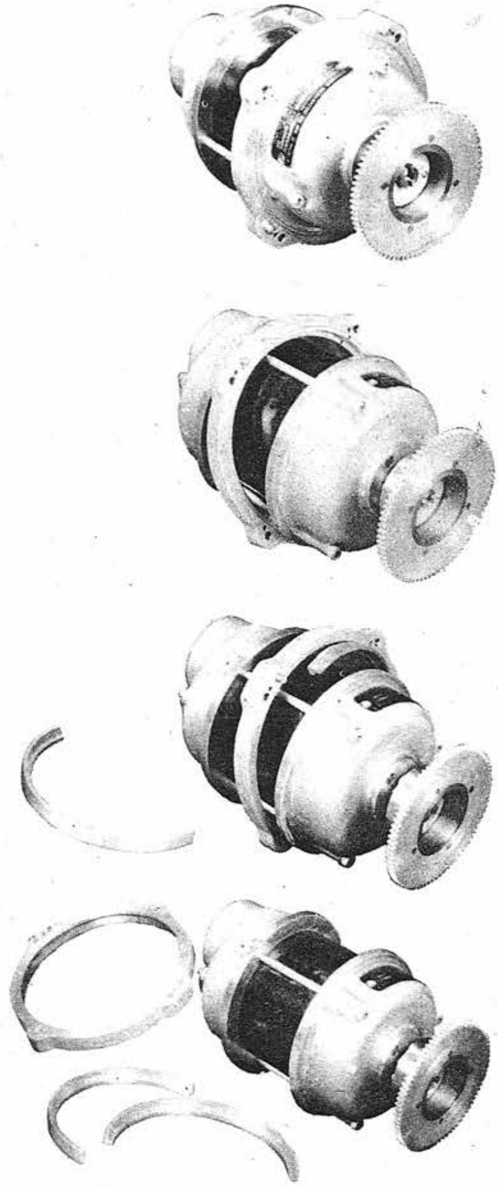
2 Remove the five screws connecting the transmitter cable leads to the terminal block on the floor of the instrument. Pull the cable behind the integrator mounting plate to the *Co* side.



3 Remove the four screws securing the transmitter frame to the back of the integrator mounting plate. Work from both sides of the instrument to reach these screws.
Remove the two screws securing the terminal block to the computer case.



4 Partially remove the transmitter in its frame. A helper should stand by on the other side of the computer to assist.

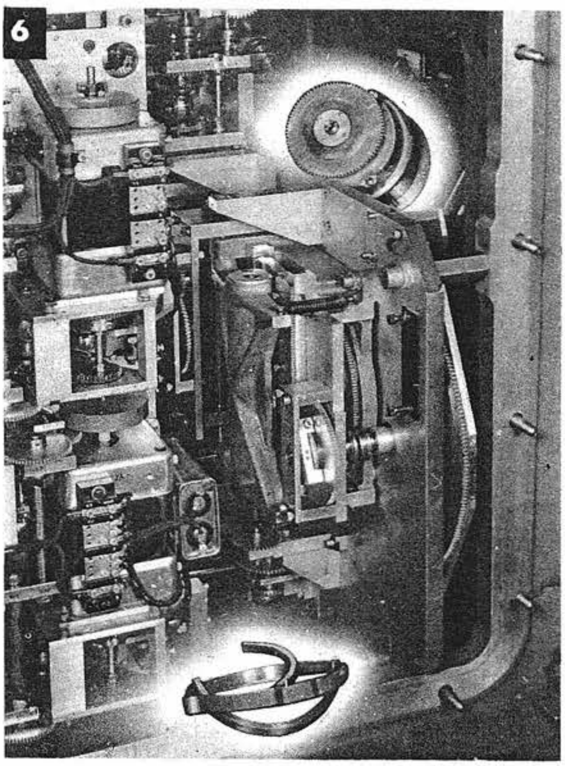


5 The transmitter will not clear the gearing behind the integrator mounting plate without being removed from the frame.

Two split-ring locking segments fit between the transmitter and the frame. The frame and the locking segments should be removed by the person on the other side of the computer. Although the frame is doweled, it should be marked in relation to the mounting plate before removal.

These pictures illustrate this special type of transmitter mounting.

6 Remove the transmitter through the *Co* aperture.

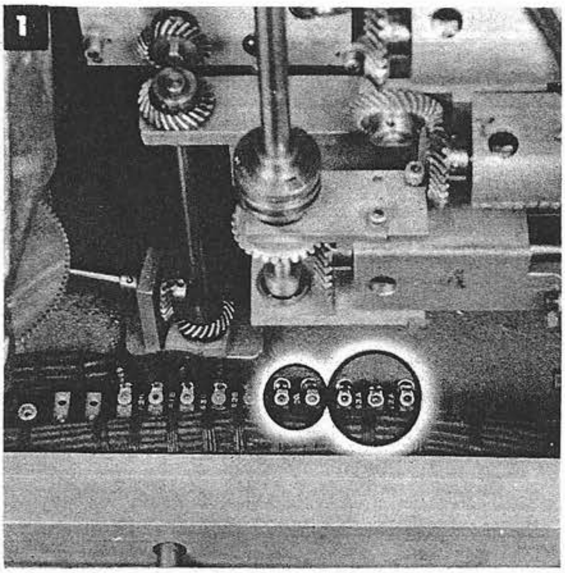


To reinstall the $\Delta cB'r$ transmitter, reverse the removal procedure.

Reinstall the *Co* mounting plate and the *Co* receiver.

Readjust clamp A-179.

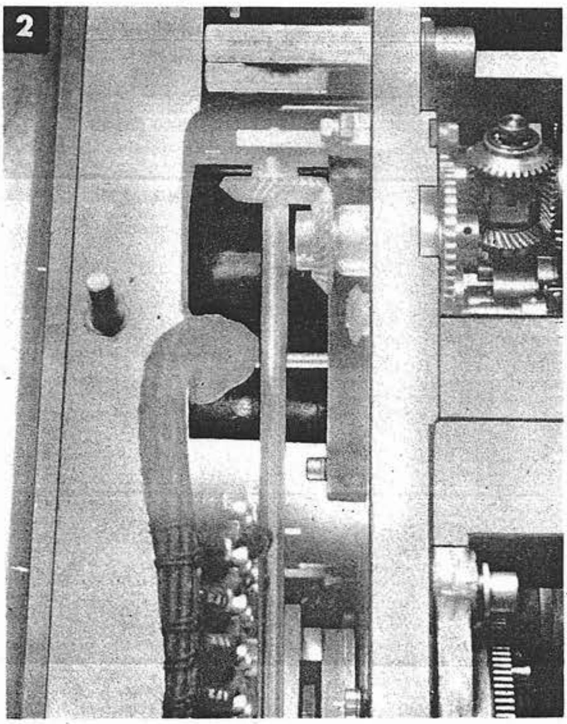
Establish the proper relationship between the *cR* dials and the *cR* intermittent drive during installation of the *cR* coupling shaft.

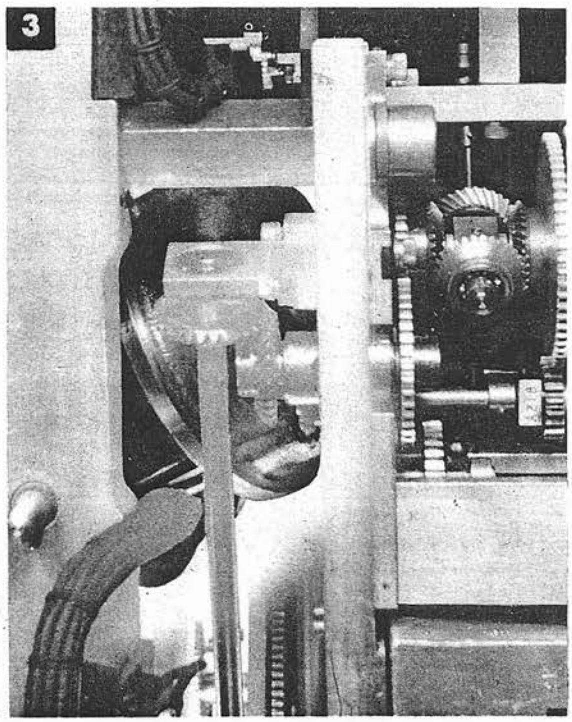


$\triangle cE$ AUTOMATIC TRANSMITTER

Co Receiver and Mounting Plate, page 666
$\triangle cB'r$ Automatic Transmitter, page 705

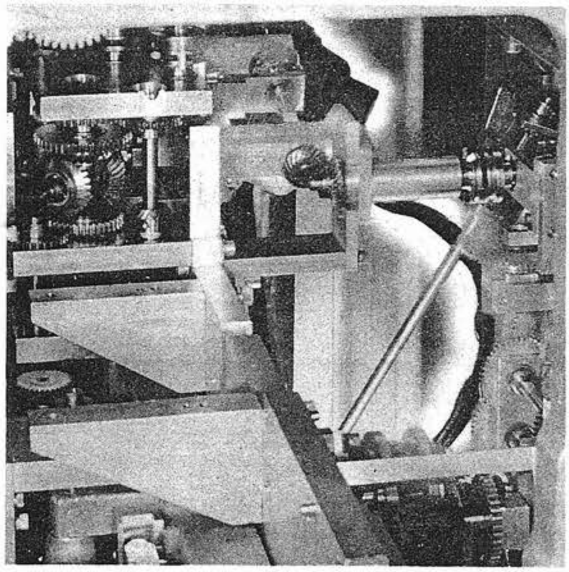
1 Remove the five screws, connecting the transmitter cable leads to the terminal block. Pull the cable behind the integrator mounting plate to the *Co* side.



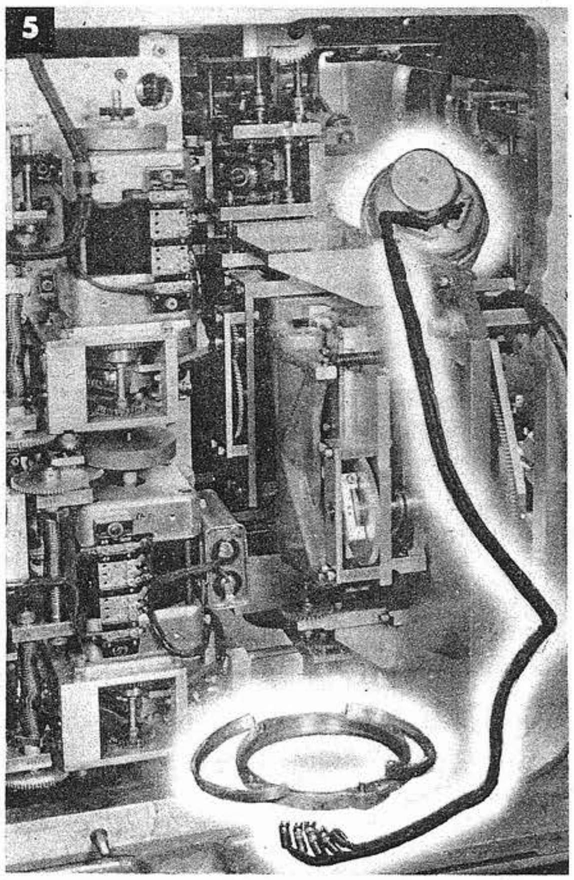


2 Remove the four screws securing the transmitter frame to the back of the integrator mounting plate.

3 Remove the frame and the split-ring locking segments as explained in the removal of the $\triangle cB'r$ automatic transmitter, page 707



5 Remove the transmitter through the *Co* aperture as in the removal of the $\triangle cB'r$ transmitter, page 707



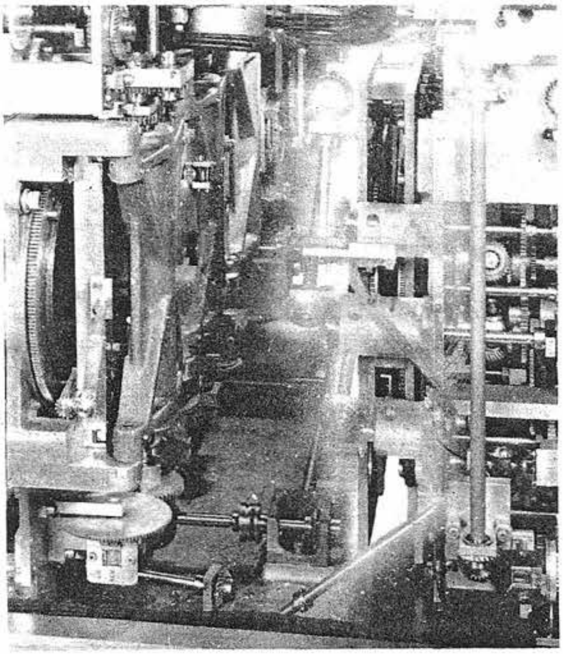
To reinstall the $\triangle cE$ automatic transmitter, reverse the removal procedure.

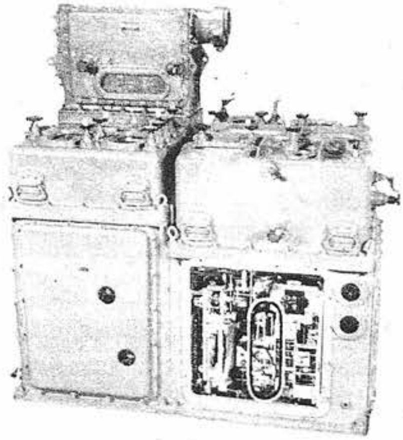
Reinstall the $\triangle cB'r$ transmitter, the *Co* mounting plate, and the *Co* receiver.

During the replacement of the *cR* coupling shaft, establish the proper relationship between the *cR* dials and the *cR* intermittent drive.

Readjust clamp A-179.

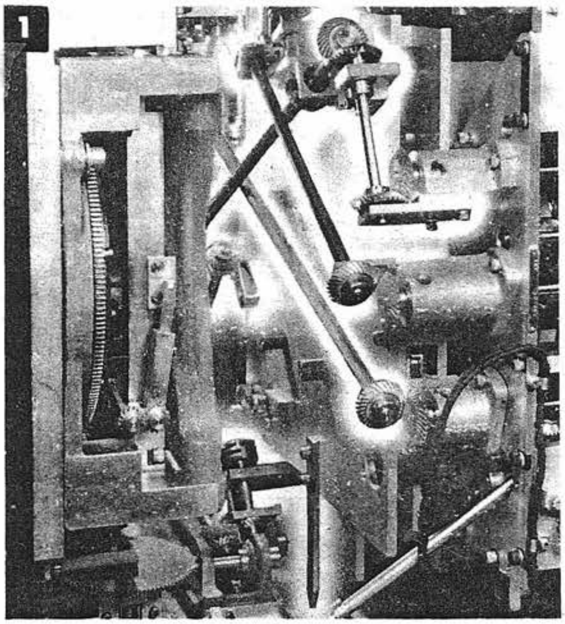
COMPLEMENTARY ERROR CORRECTOR

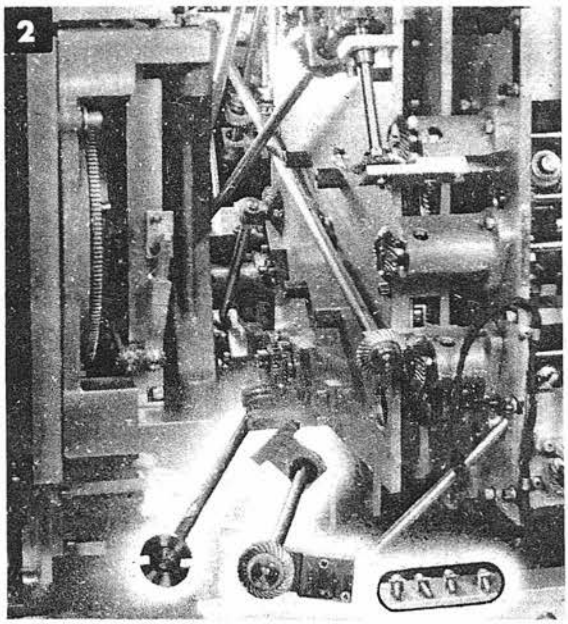




WrD + *KRdBs* Follow-up, page 684

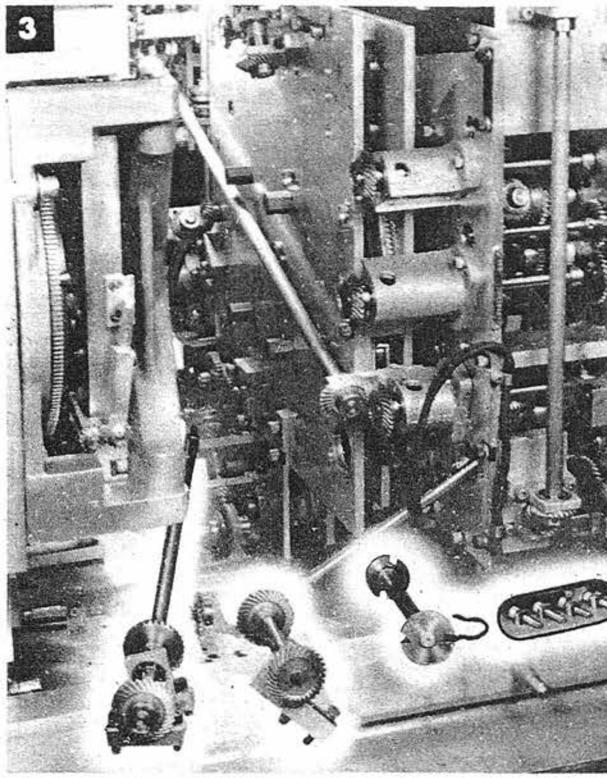
NOTE:
The complementary error corrector may be removed by either of two methods: The method shown here is more difficult, although it involves removal of fewer parts; the alternate method is shown in the preliminary procedure for the removal of the horizontal wind component solver, page 684





1 It is necessary to remove all the shafts crossing the corrector.

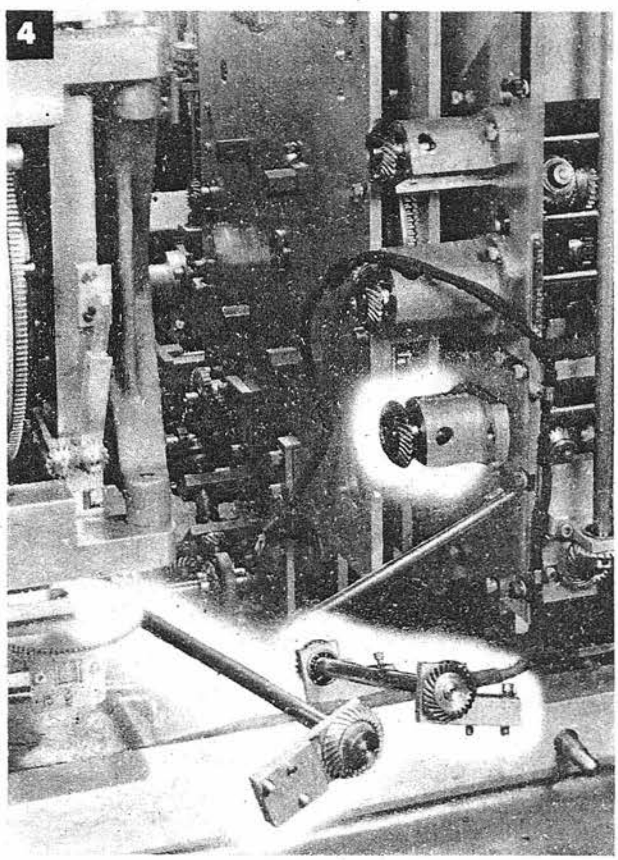
2 Remove the locking spring from the long coupling shaft. Remove the shaft.
Remove the screws from the short shaft assembly which connects with the middle bevel gear at the edge of the mechanism.
Remove the assembly.



3 Remove the screws securing the short shaft assembly which connects with the top bevel gear. Remove the assembly.

Remove the screws from the long shaft assembly that connects with the assembly just removed. Remove the assembly.

Remove the short coupling shaft near the center at the top of the mechanism.

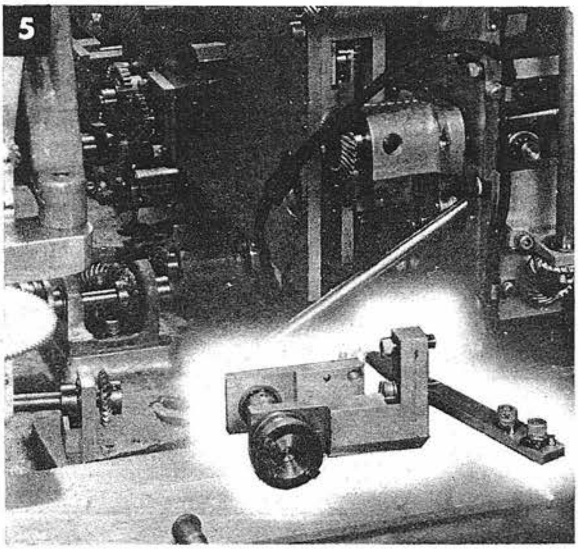


4 Remove the screws from the lowest bevel-gear adapter.

Remove the two screws from the hanger attached to the flat side of the adapter.

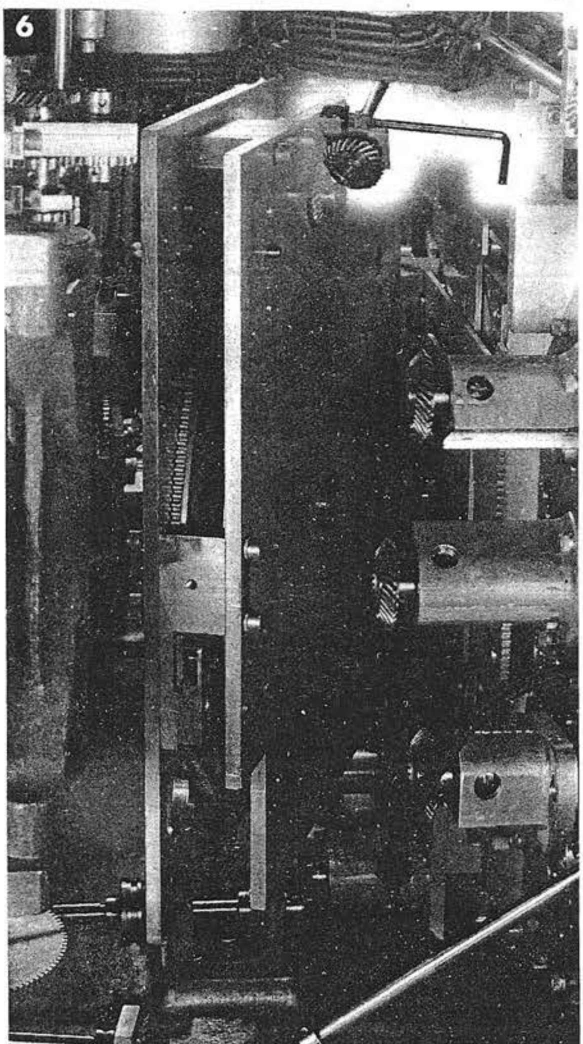
Remove the two screws from the other end of the shaft assembly. Remove the assembly.

Remove the screws from the short bevel-gear shaft assembly at the back of the mechanism. Remove this assembly.



5 Remove the screws from the hangers of the short coupling shaft below the complementary error corrector. Remove the shaft assembly.

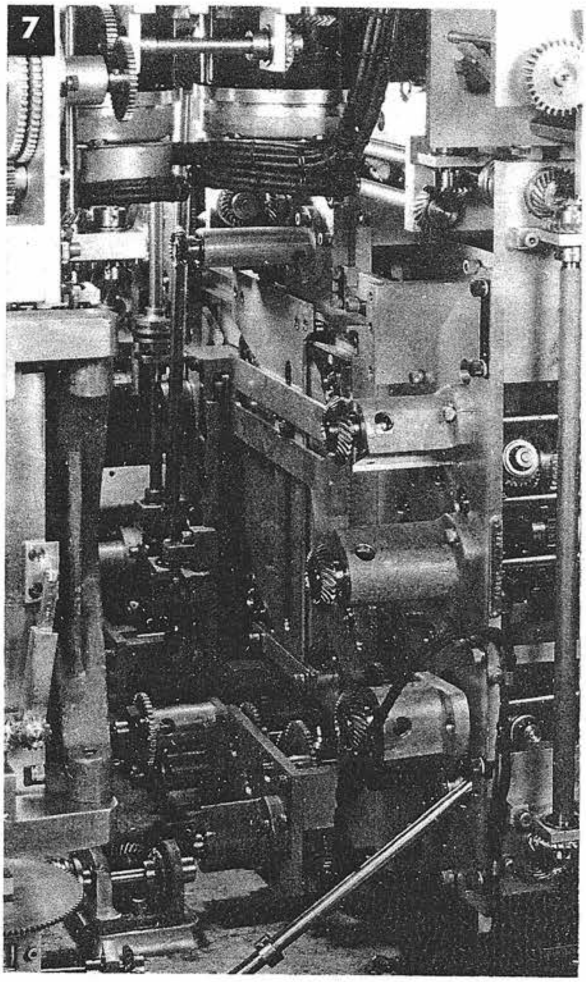
Remove the screws from the supporting leg at the bottom center of the unit. Remove the leg.



6 From the opposite side of the computer, remove the two screws from the *Ds* shaft assembly on which clamp A-110 is mounted.

Remove the screws securing the complementary error corrector. Move the mechanism away from the bevel-gear adapters.

Remove the two screws from the short shaft assembly attached to the rear plate. Remove the shaft assembly.



7 Remove the complementary error corrector.

To reinstall the complementary error corrector, reverse the removal procedure. Reinstall the other mechanisms removed.

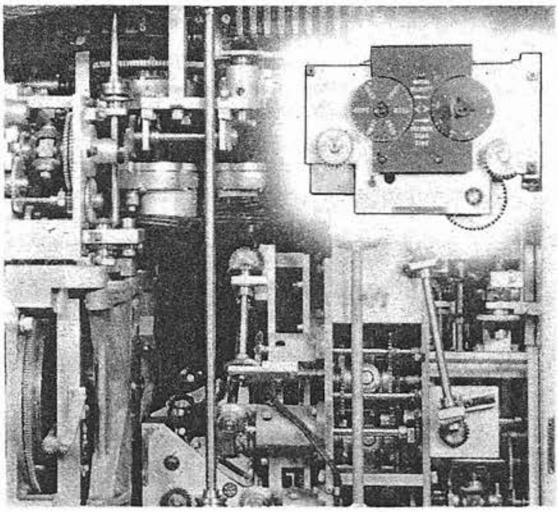
NOTE:
When reinstalling the *Rj*, *Vj*, and *Dj* coupling shafts, adjust the counters to the limit stop by proper mating of the couplings or gears, or readjust clamps A-234, A-235, A-88, A-501, A-87, A-500, and A-86.

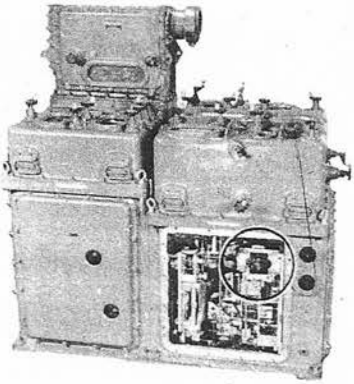
Readjust clamps A-108, A-157, A-100, A-135, A-134, A-131, A-110, A-107, A-229 and A-230.

Check clamps A-104, A-103, A-102, A-106, A-109 and A-105.

Run tests.

I. V., Tg DIAL GROUP





1 Remove the four screws securing the mechanism. One is reached through the hole just below the *I.V.* dial.

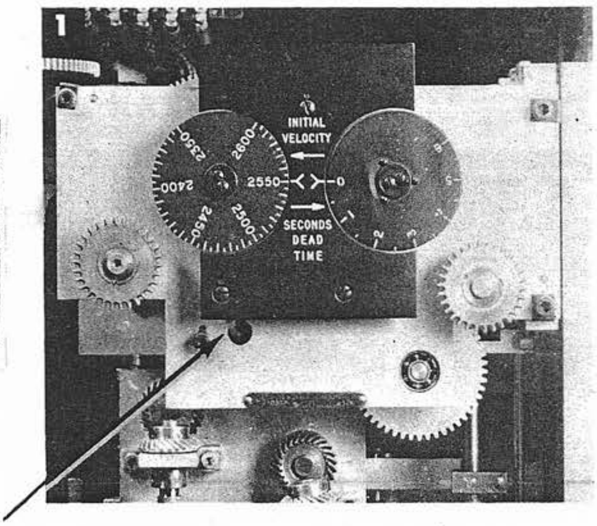
2 The other three screws are in the large mounting plate at the front.

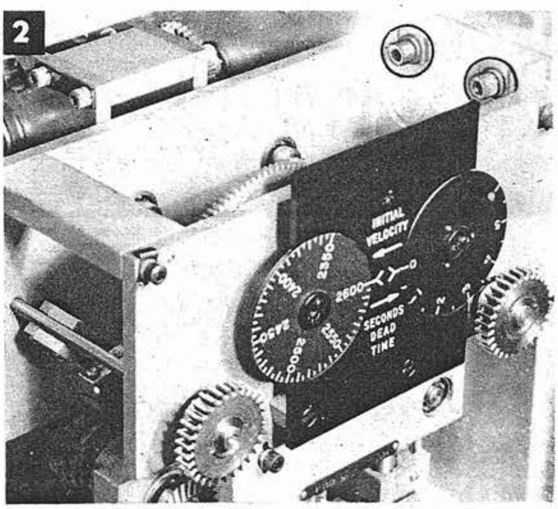
3 Remove the mechanism.

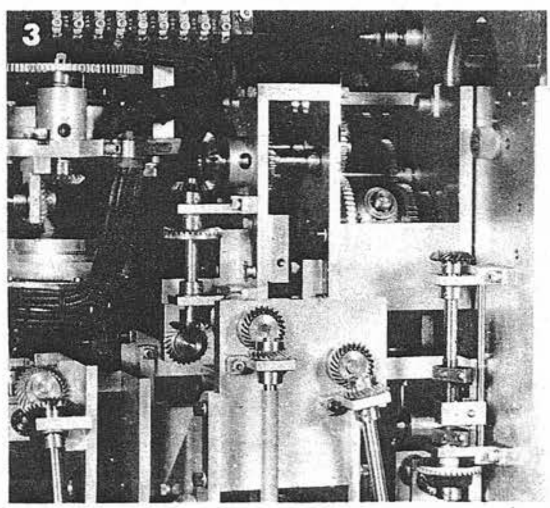
To reinstall the dial group, reverse the removal procedure.

Readjust clamps A-535, A-536 and A-188.

Check clamps A-181, A-135 and A-81.

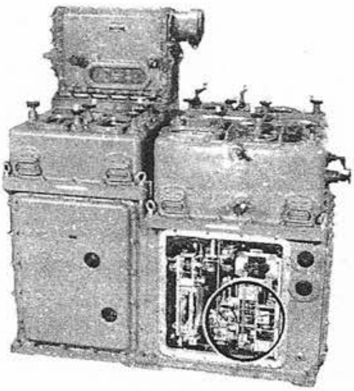


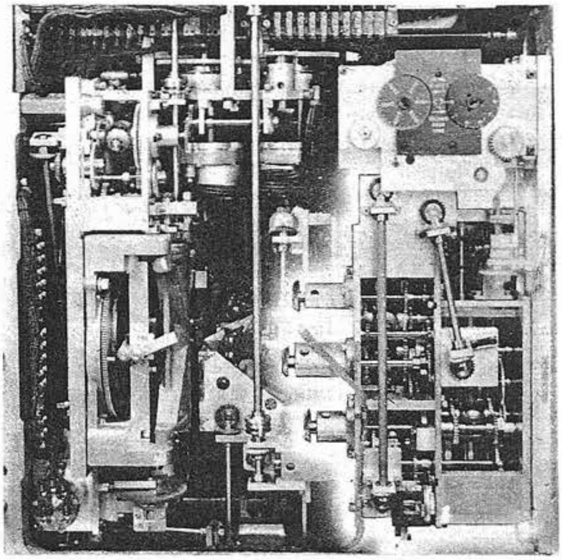




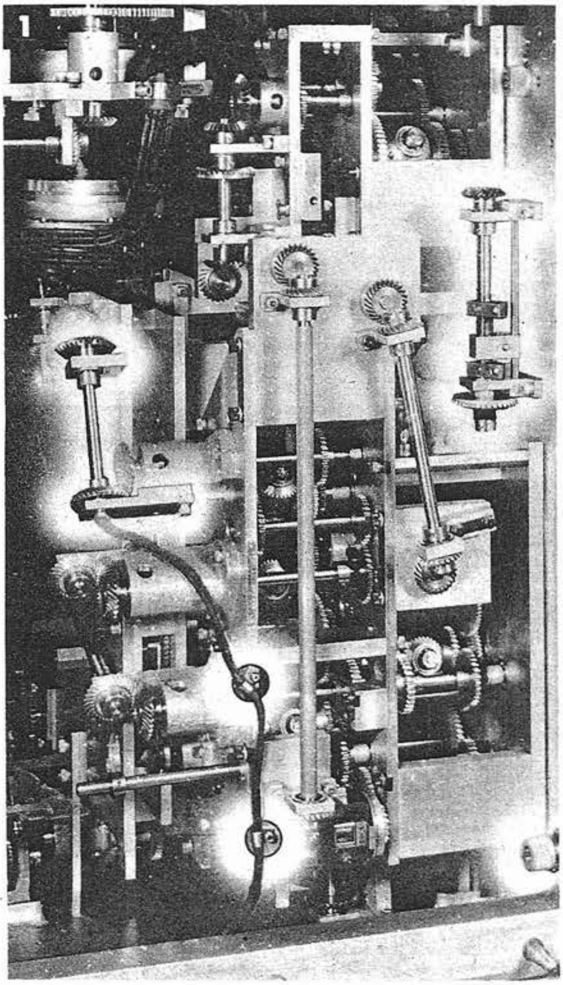
Gene Slover's US Navy Pages | Table of Contents

PREDICTION MULTIPLIERS INPUT GEARING

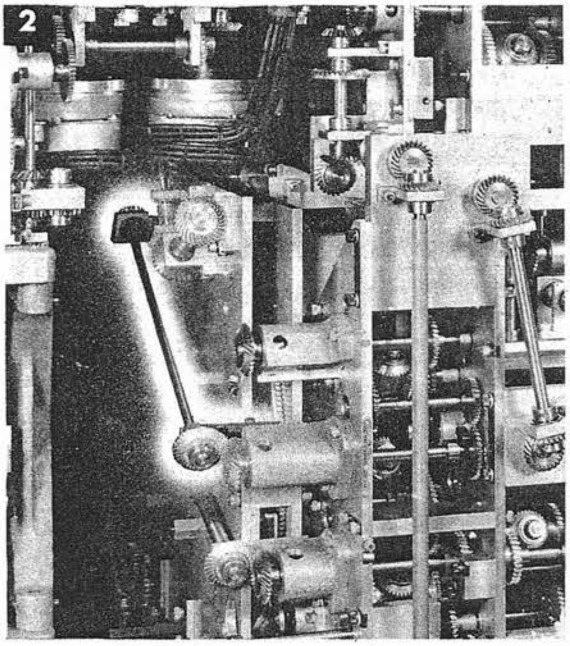


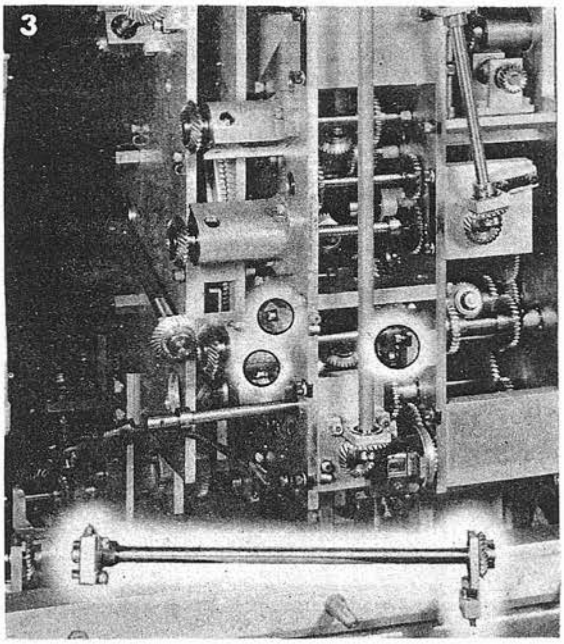


I.V., *Tg* Dial Group, page 714
WrD + *KRdBs* Follow-up, page 684



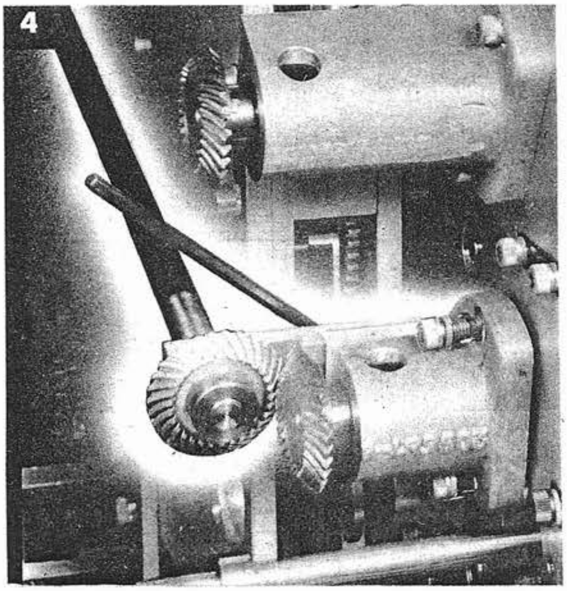
1 Remove the four screws securing the hangers for the *Tg* limit stop, L-14. Remove the limit stop.
Remove the four screws from the shaft assembly connecting with the bevel gear at the upper left of the mechanism. Remove the assembly.
Remove the large screw securing the lower corner of the large mounting plate.
Loosen the two screws securing the cable clamps.
Free the cable.

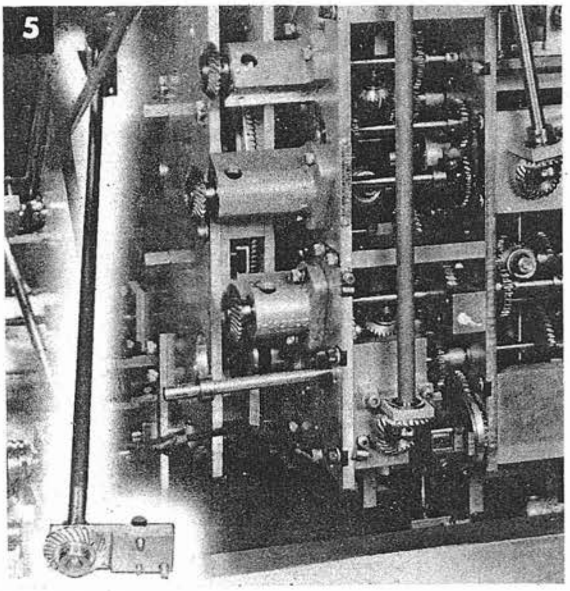




2 Remove the four screws from the shaft assembly connecting with the middle bevel-gear adapter.

3 Remove the shaft assembly.
Remove the two screws from the lowest bevel-gear adapter.
Remove the two screws from the other end of the shaft assembly connecting with the lowest bevel gear.

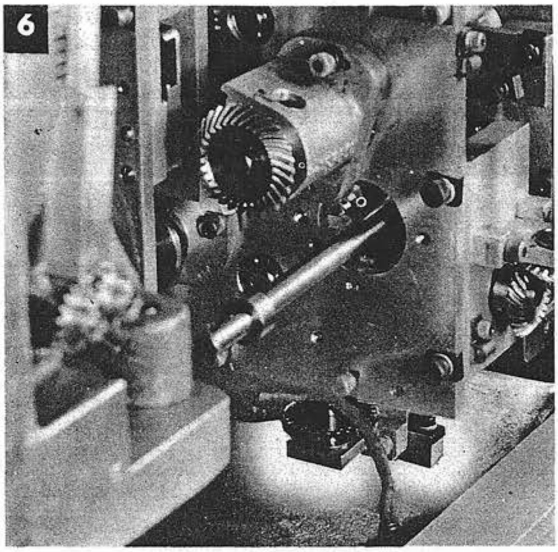




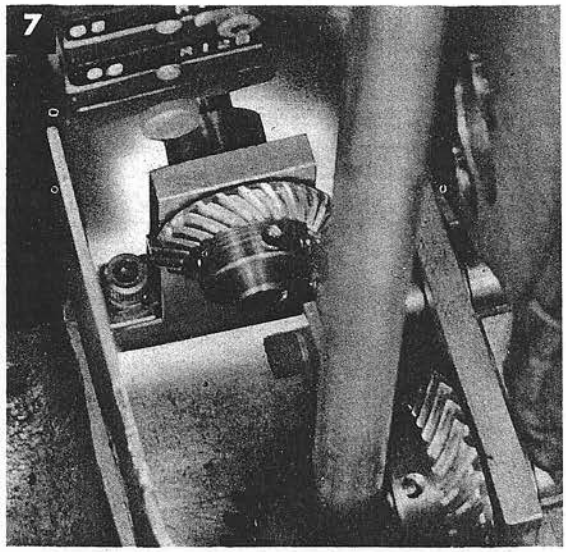
4 Remove the two screws from the hanger attached to the back of the lowest adapter.

5 Move the shaft assembly out of the way.

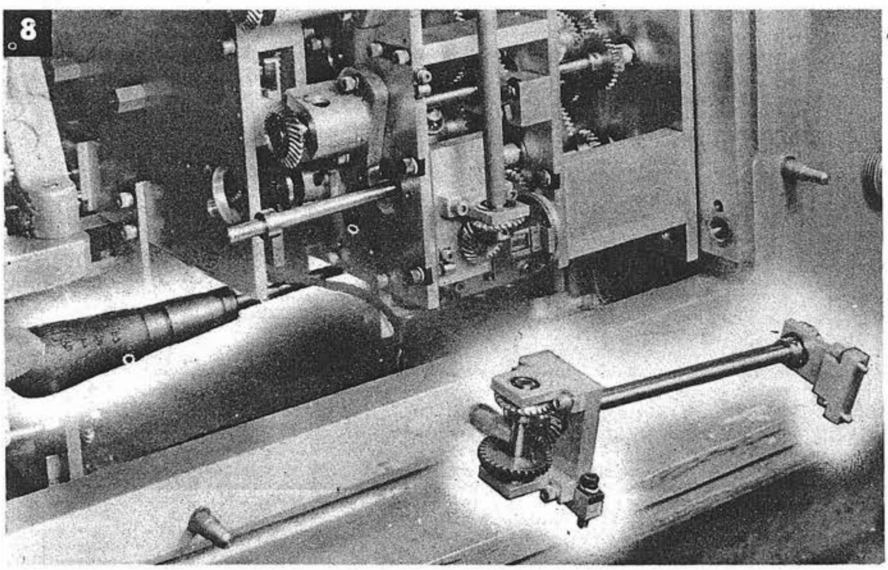
Gene Slover's US Navy Pages | Table of Contents



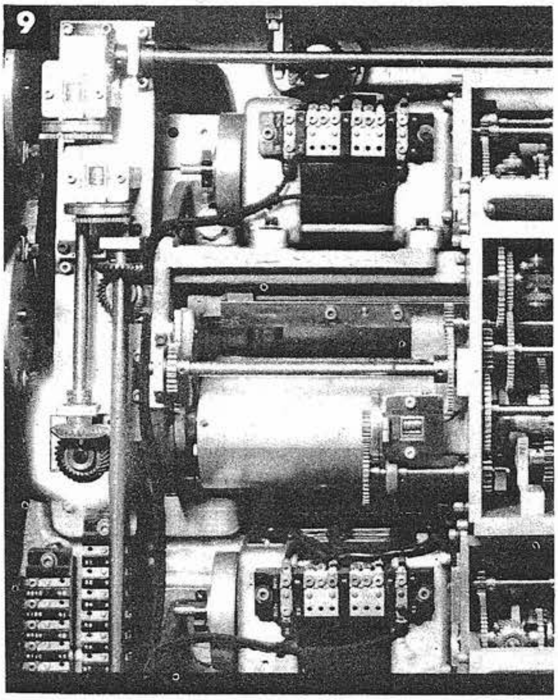
6 Remove the two screws from the hanger at the prediction-unit end of the shaft assembly connecting the ballistic and prediction units. To reach these screws it may be necessary to remove the four screws from the shaft assembly mounted on this hanger.



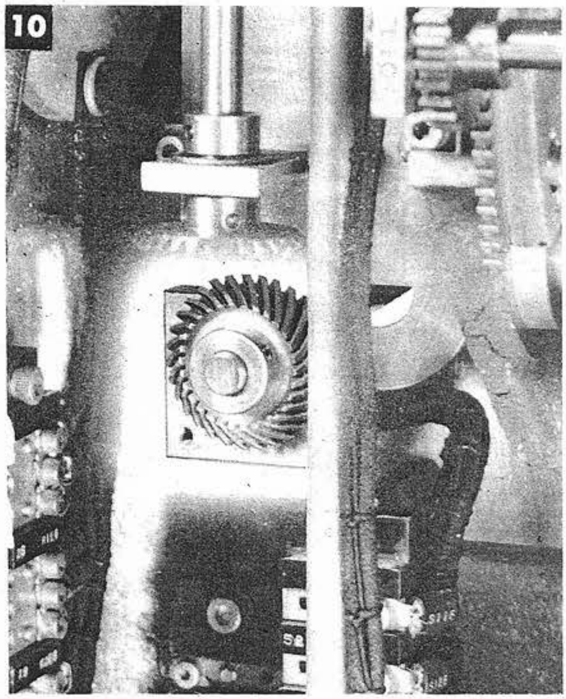
7 Remove the two screws from the hanger at the ballistic-unit end of the assembly.



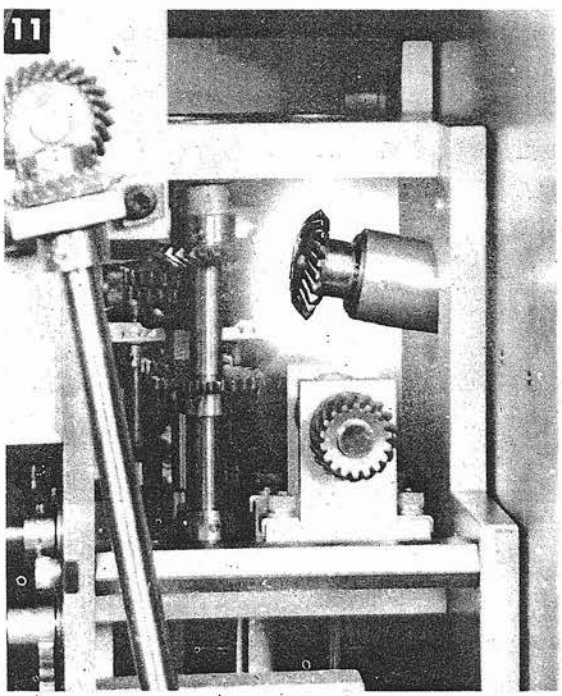
8 Remove the shaft assembly through the prediction side of the mechanism.
Remove the screw securing the prediction multipliers input gearing.



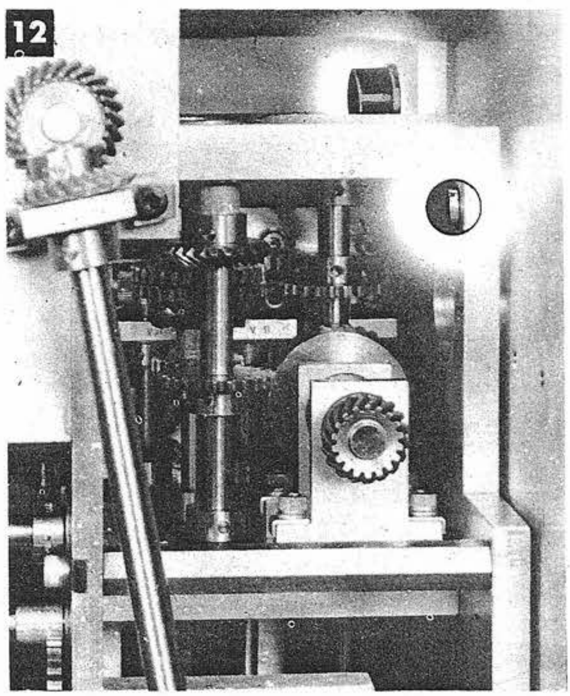
9 Remove the two screws securing the hanger to the left of the *Tf/R2* ballistic computer.



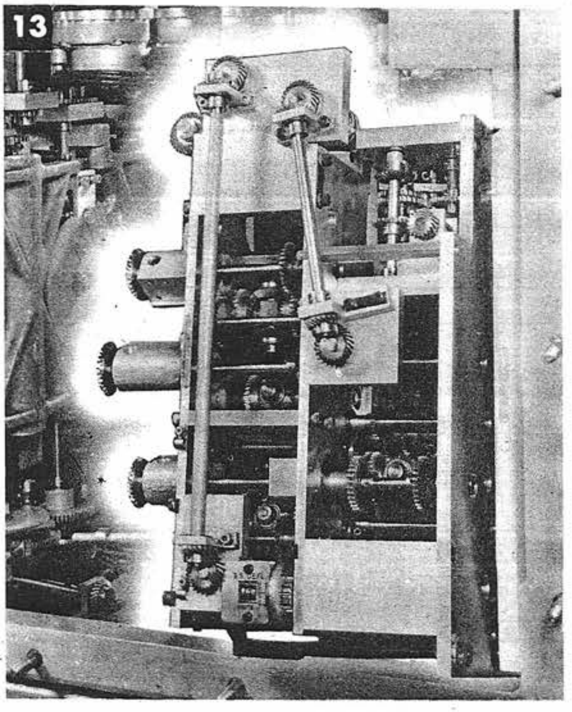
10 Remove the two screws securing the adapter directly behind this hanger.

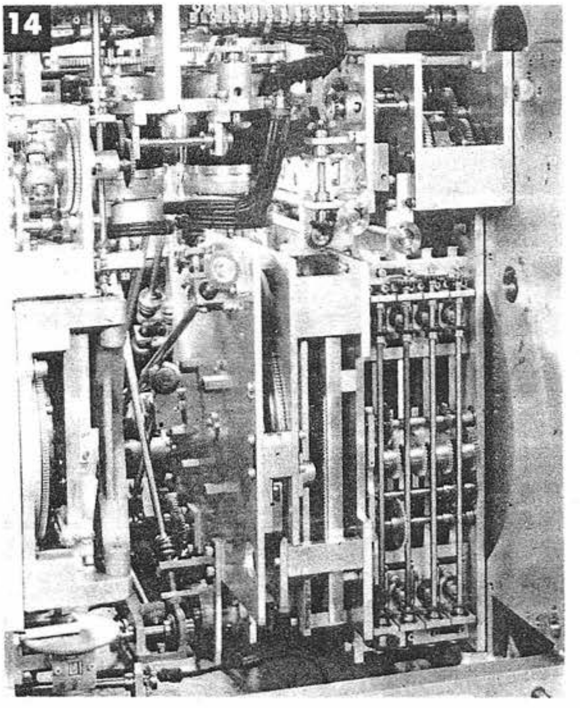


11 Slide the adapter and shaft assembly as far as it will go toward the ballistic-unit side.



12 Back out the screw dowel. Remove the upper screw.





13 Back out the two screw dowels. Remove the remaining screw. Support the gearing unit while removing this screw. Tilt the mechanism to clear the instrument.

14 Remove the prediction multipliers input gearing.

To reinstall the prediction multipliers input gearing, reverse the removal procedure.

Reinstall all mechanisms removed.

Readjust clamps A-108, A-81, A-135, A-80.

Check clamp A-104.

Readjust clamps A-79, A-134, A-535, A-536, A-188, A-181, and A-132.

Check clamp A-203.

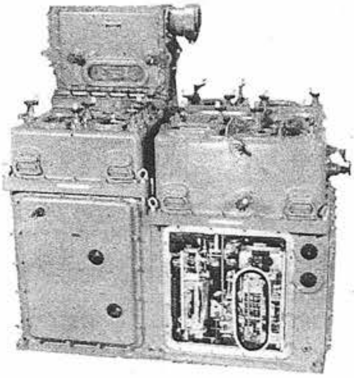
Readjust clamps A-133, A-131, and A-78.

Check clamps A-102, A-110, A-107, and A-103.

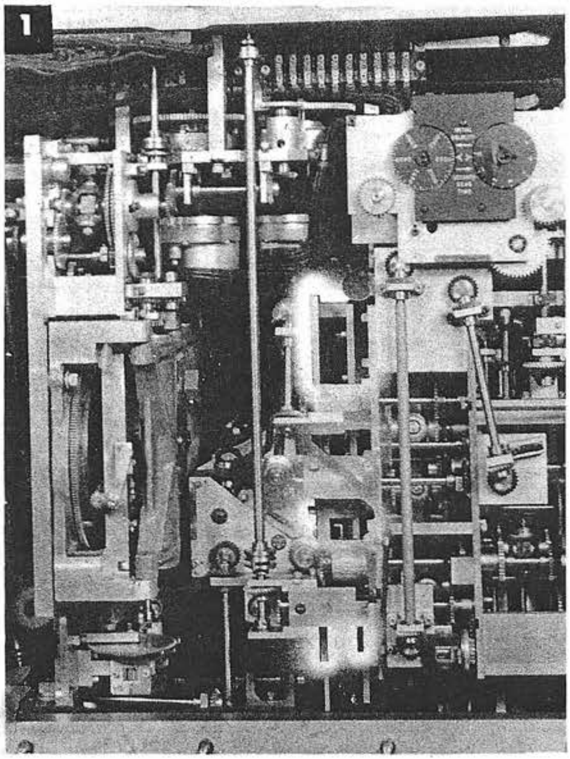
Readjust clamps A-229 and A-230.

Run tests.

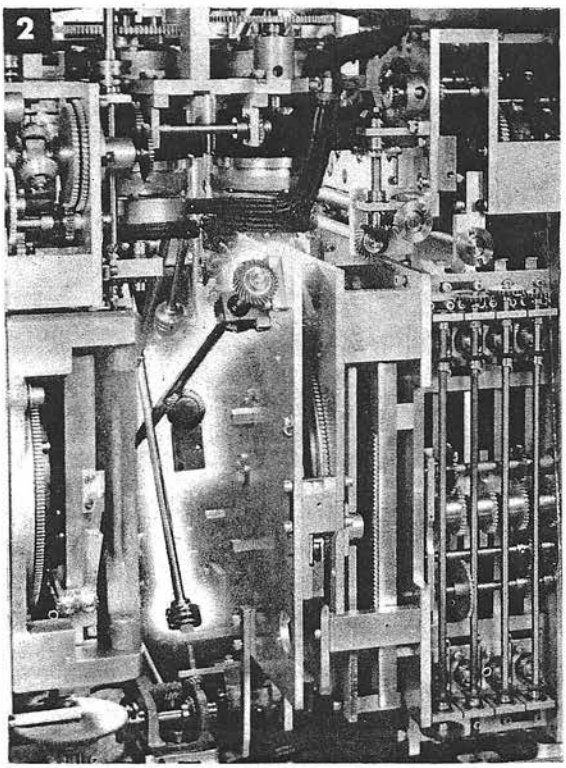
HORIZONTAL WIND COMPONENT SOLVER



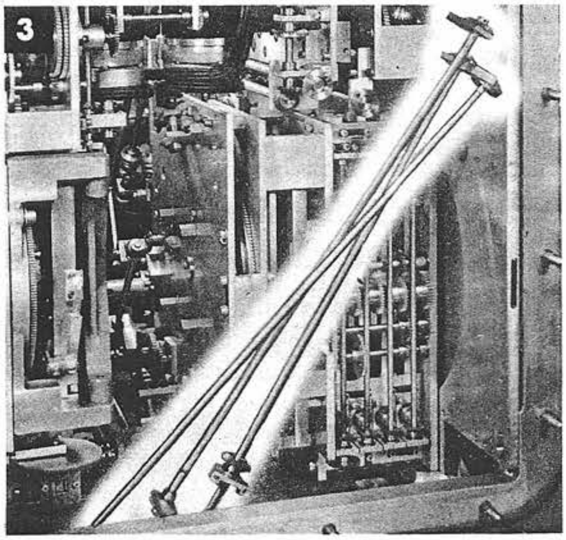
$WrD + KRdBs$ Follow-up, page 684
I.V., $T\acute{g}$ Dial Group, page 714
Prediction Multipliers Input Gearing, page 715



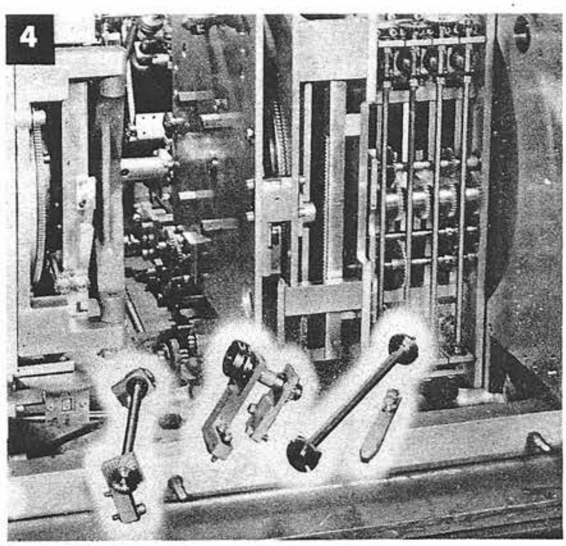
1 The first step in the removal of the wind component solver is the removal of the complementary error corrector. The procedure outlined here may be used instead of the method given on page 710



2 Remove the locking springs from the long coupling shaft. Remove the shaft.
Remove the screws from the long shaft assembly mounted diagonally, with its upper hanger on the complementary error corrector.



3 Remove the third long shaft assembly, one end of which was previously loosened.

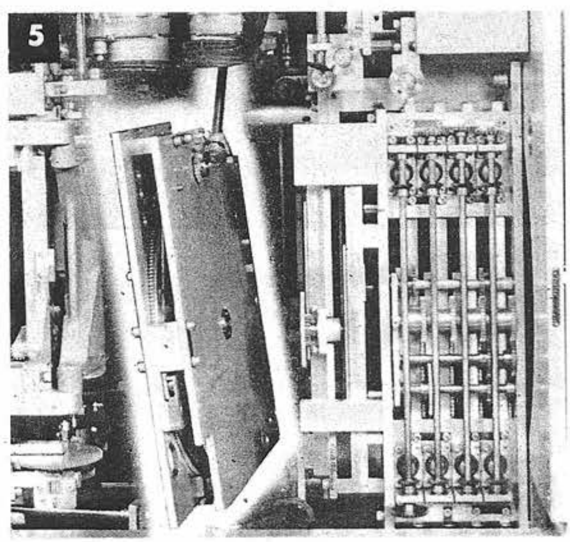


4 Remove the locking springs from the coupling shaft connecting with the short shaft at the top of the complementary error corrector. Remove the shaft.

Remove the two screws securing the supporting leg at the bottom of the mechanism. Remove the leg.

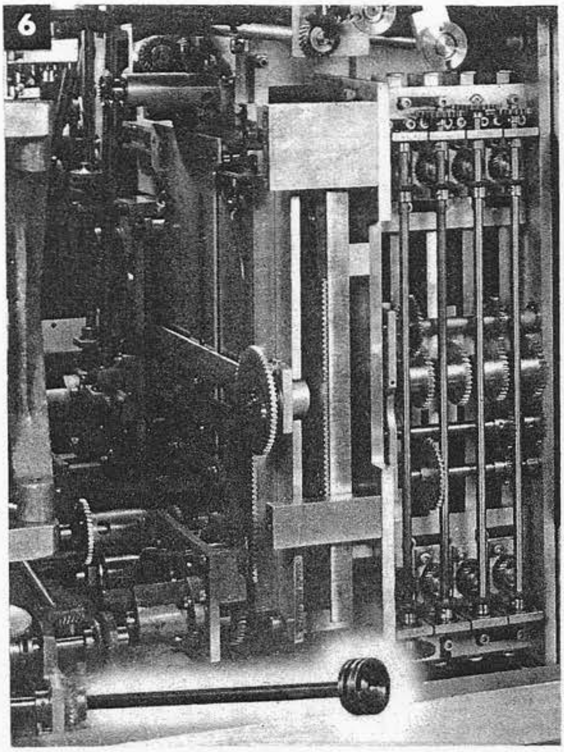
Remove the screws securing the short coupling shaft near the bottom of the mechanism. Remove the shaft.

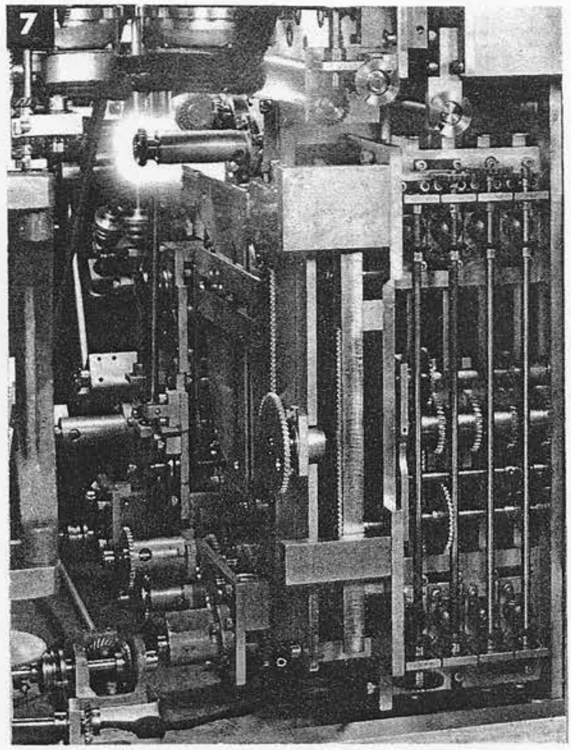
Remove the screws securing the short shaft assembly which is mounted diagonally between the inner edge of the complementary error corrector and the floor of the computer. Remove the shaft.



5 From the other side of the computer, remove two screws from the *Ds* shaft assembly where clamp A-110 is mounted.

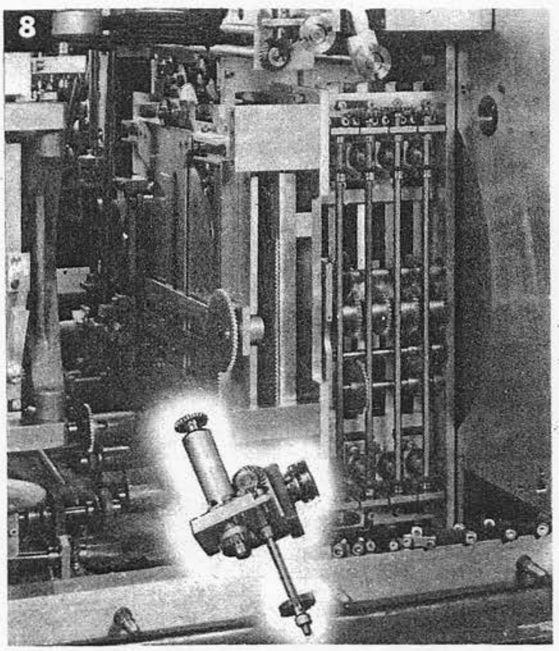
Remove the screws securing the complementary error corrector. Remove the mechanism.

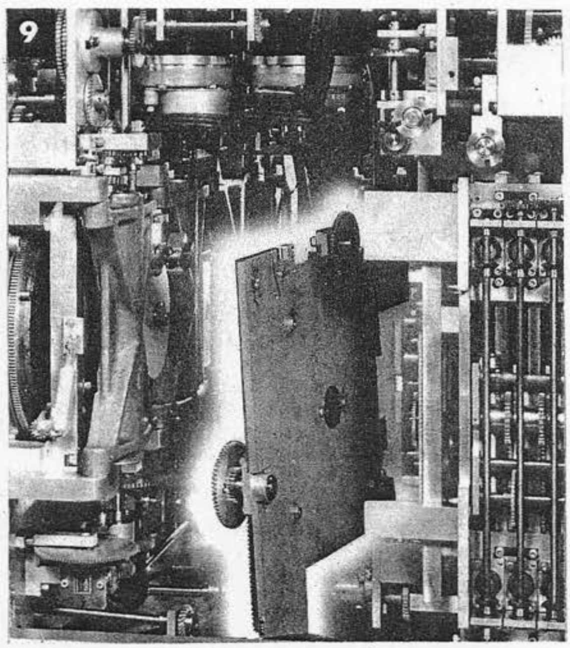




6 Remove the locking spring from the *Sw* coupling shaft directly above the horizontal wind component solver. Remove the shaft.

7 Remove the screws securing the plate of the small gearing unit above the solver.





8 Remove the plate with the adapter and one shaft.

9 Remove the eight screws securing the horizontal wind component solver.
Remove the mechanism.

Gene Slover's US Navy Pages | Table of Contents

To reinstall the horizontal wind component solver, reverse the removal procedure.

Reinstall the other mechanisms removed.

The following adjustment procedure applies to the reinstallation of:

Horizontal wind component solver
Elevation wind component solver
Wind component solvers output gearing
Range rate corrector
Prediction multipliers
Prediction multipliers output gearing

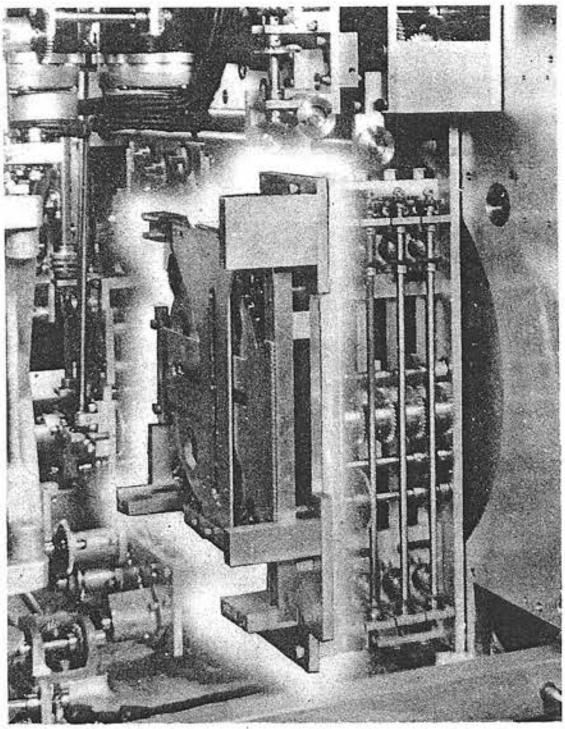
Readjust the following clamps in the order given:

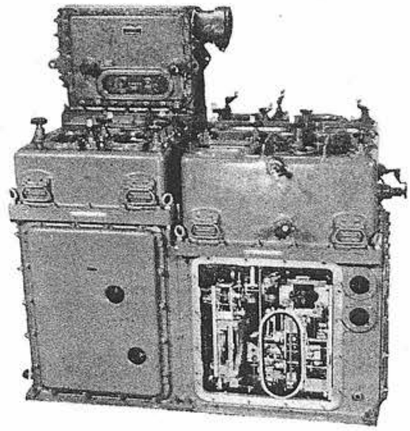
A-500	A-157	A-75
A-501	A-181	A-76
A-234	A-101	A-203
A-235	A-72	A-104
A-86	A-106	A-220
A-87	A-100	A-184
A-88	A-79	A-180
A-233	A-134	A-110
A-108	A-81	A-103
A-109	A-135	A-221
A-154	A-535	A-107
A-155	A-188	A-133
A-139	A-132	A-131
A-82	A-84	A-102
A-536	A-183	A-217
A-198	A-80	A-78
A-105	A-74	A-229
		A-230

NOTE:
If the *Dj,* and *Vj,* and *Rj* dials can be rematched to their limit stops through mating couplings or gear meshes, it will not be necessary to readjust clamps A-500, A-501, A-234, A-235, A-86, A-87 and A-88.

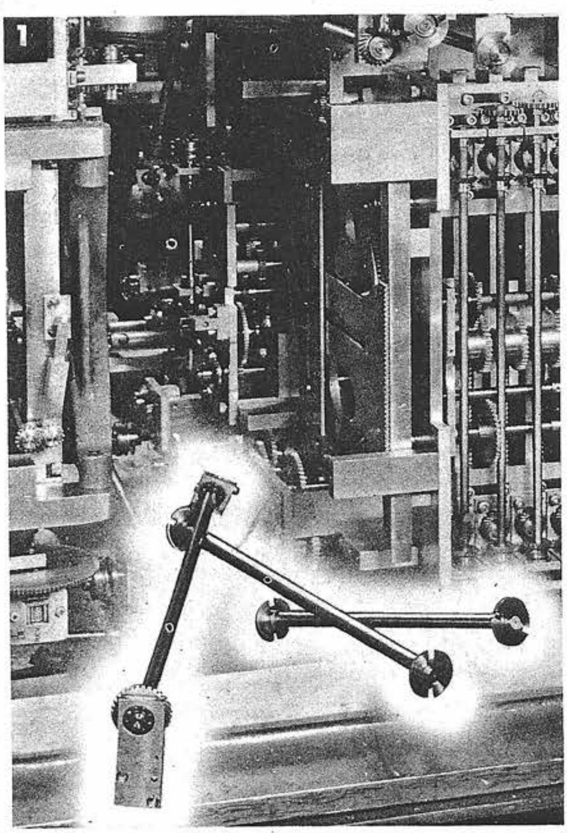
Run all tests.

ELEVATION WIND COMPONENT SOLVER





I.V., *Tg* Dial Group, page 714
WrD + *KRdBs* Follow-up, page 684
Prediction Multipliers Input Gearing, page 715
Complementary Error Corrector, page 710
Horizontal Wind Component Solver, page 720



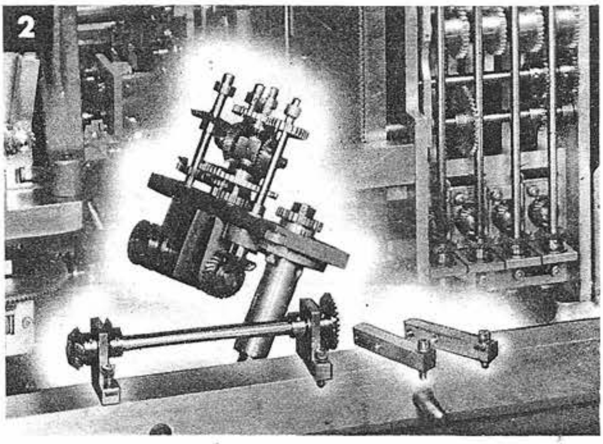
1 Remove the locking springs from the *Bw* and *Rj* coupling shafts above the elevation wind component solver. Remove the shafts.

Remove the screws from the *Ds* shaft assembly, one end of which is mounted on the elevation wind solver, and the other almost directly above it. Remove this assembly.

2 Remove the two small brackets that supported the horizontal wind component solver.

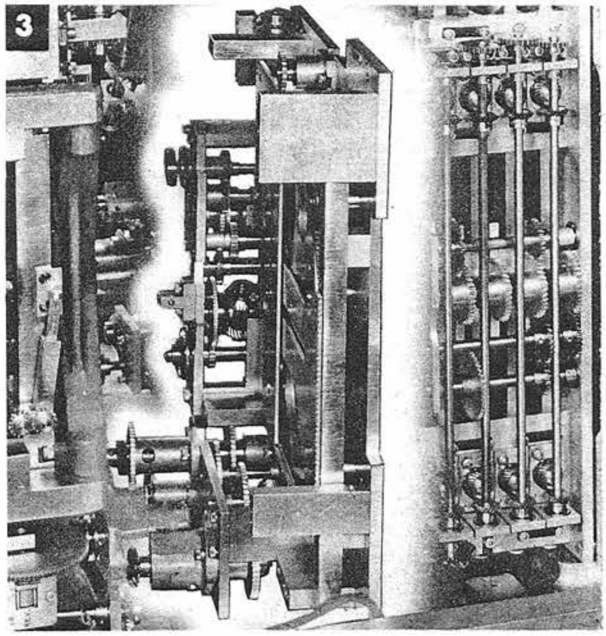
Remove the screws from the short *E* shaft assembly near and parallel to the floor of the computer. Remove this assembly.

Remove the shafts from the small gearing unit, the top plate of which was removed with the horizontal wind solver. These shafts are above the elevation wind solver. (In the picture these shafts have been put back into the plate bearings.)

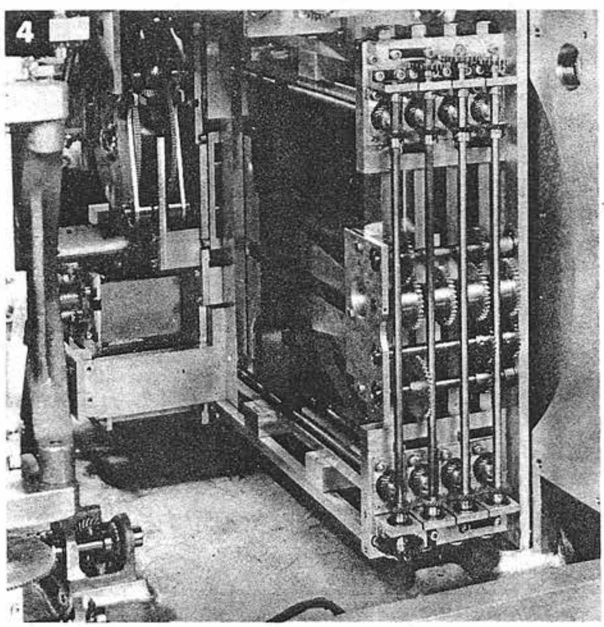


3 Remove the screws securing the elevation wind component solver.

Free the dowels from the mounting and tilt the mechanism.



4 Remove the elevation wind component solver.

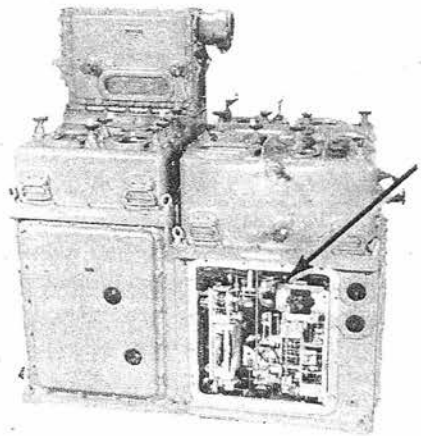


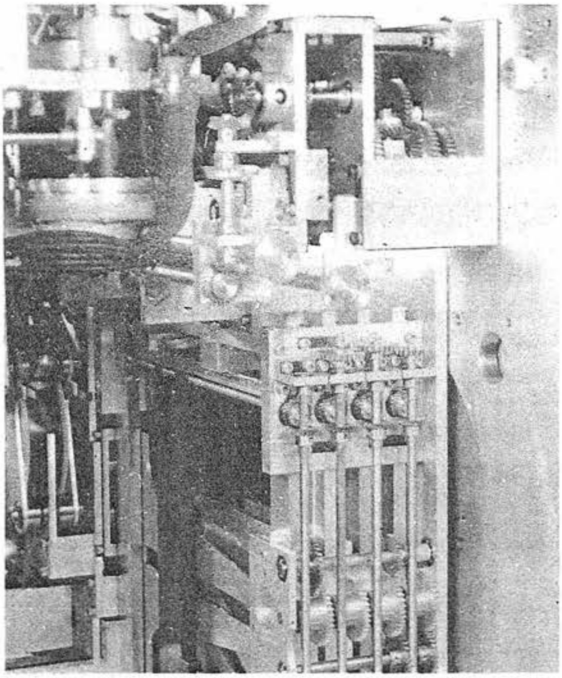
To reinstall the mechanism, reverse the removal procedure.

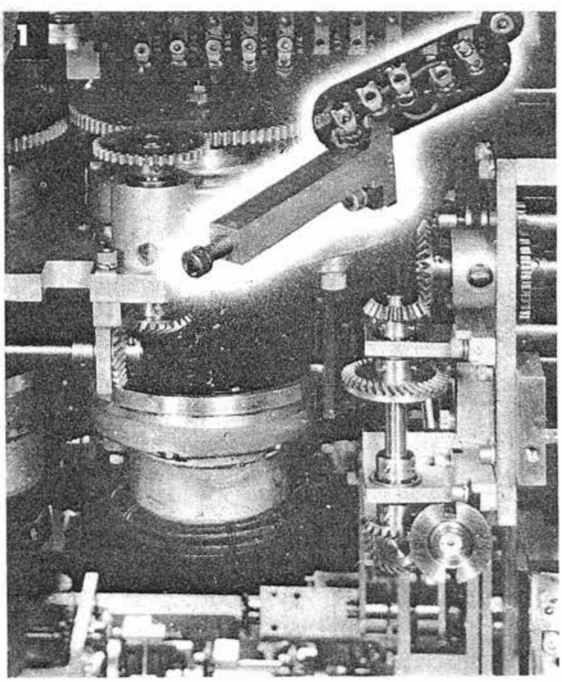
Reinstall all the units removed.

Readjust according to the instructions for reinstalling the horizontal wind component solver, page 723

WIND COMPONENT SOLVERS OUTPUT GEARING



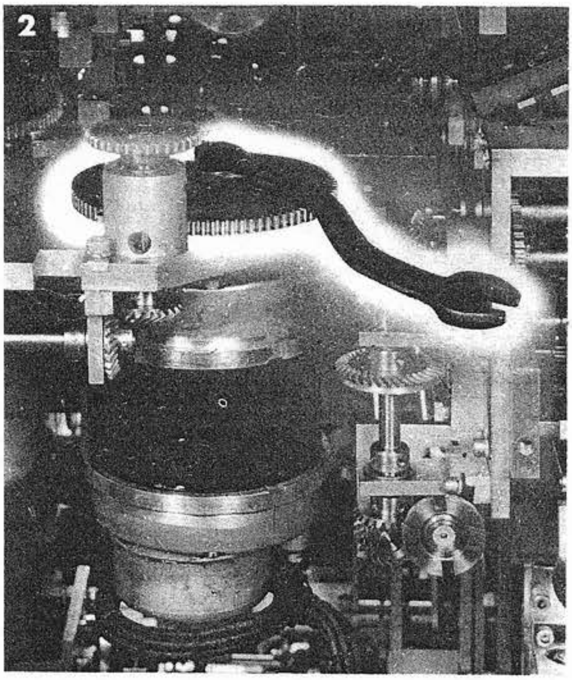


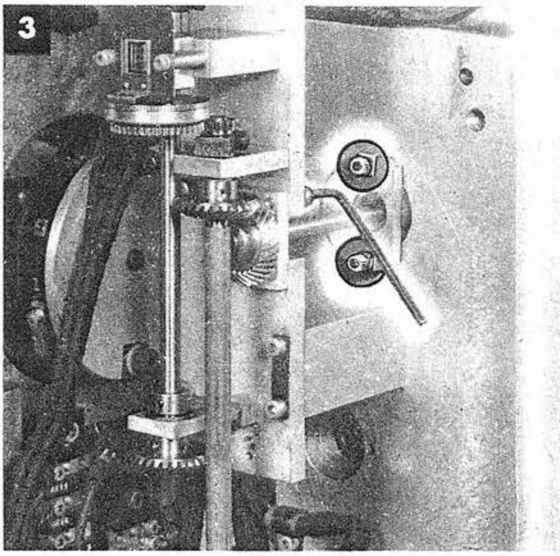


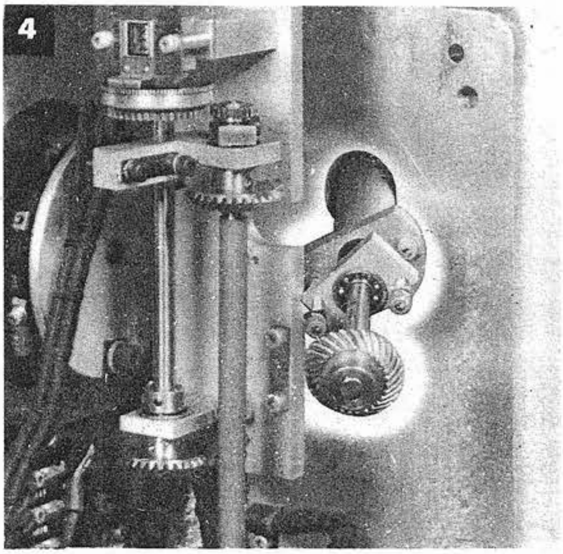
I.V., Tg Dial Group, page 714
$WrD + KRdBs$ Follow-up, page 684
Prediction Multipliers Input Gearing, page 715
Complementary Error Corrector, page 710
Horizontal Wind Component Solver, page 720
Elevation Wind Component Solver, page 724
Time of Flight (Tf) Ballistic Computer, page 663

1 Remove the five screws connecting the $\triangle cE$ indicating transmitter cable leads to the terminal block.
Remove the three screws securing the supporting post to the front edge of the transmitter mounting plate. Remove the post.
Remove the two screws securing the terminal block and push it to one side.

2 Loosen the three screws securing the transmitter to the mounting plate. Turn the eccentric blocks so that the transmitter will clear. Lower the transmitter until the rotor gear rests on the mounting plate.
Remove the nut from the rotor gear. Remove the transmitter, the gear, the nut, and the washer.

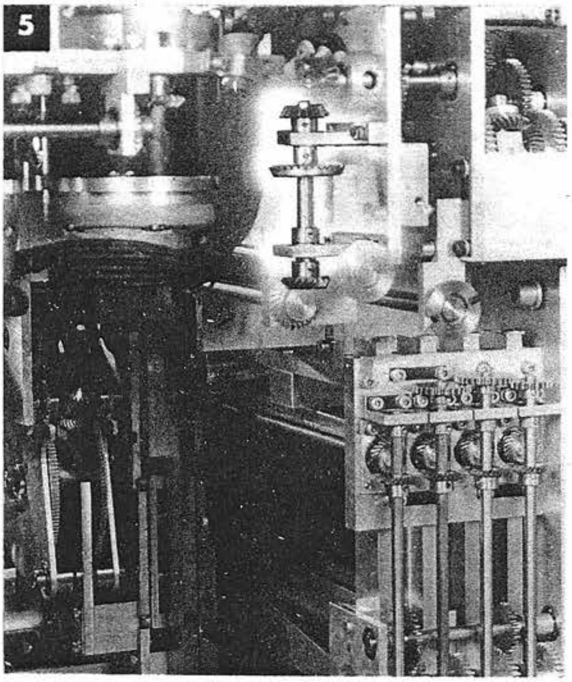




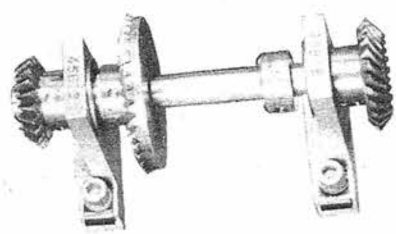


3 Remove the four screws securing the hanger and adapter just below the $Vf + Pe$ master counter.

4 Pull the adapter and the shaft toward the ballistic side of the computer to clear the gearing unit to be removed.

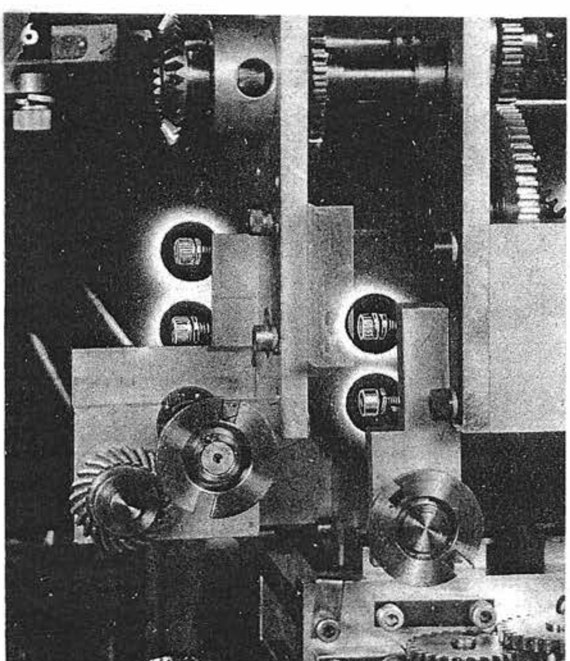


5 Remove the four screws securing the vertical shaft assembly to the mechanism to be removed.

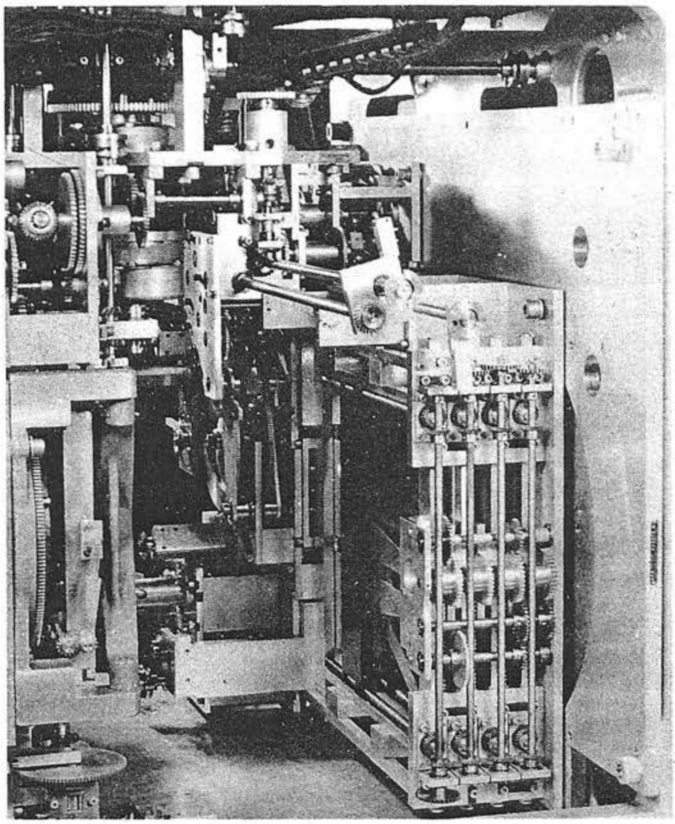


Remove the shaft assembly.

Remove the screws securing the hanger of the shaft that runs diagonally up to the mid-section of the wind component solvers output gearing.



6 Remove the four screws securing the two long horizontal shaft assemblies. Back out the two screw dowels and remove the three screws. Support the gearing mechanism while removing the last screw. While the wind component solvers output gearing is being removed be careful not to bend the two long horizontal shaft assemblies.



7 Remove the wind component solvers output gearing.

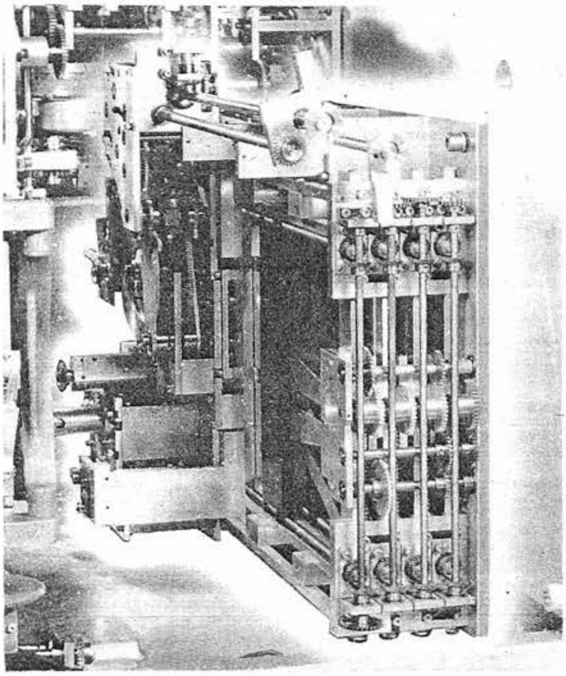
To reinstall the wind component solvers output gearing, reverse the removal procedure.

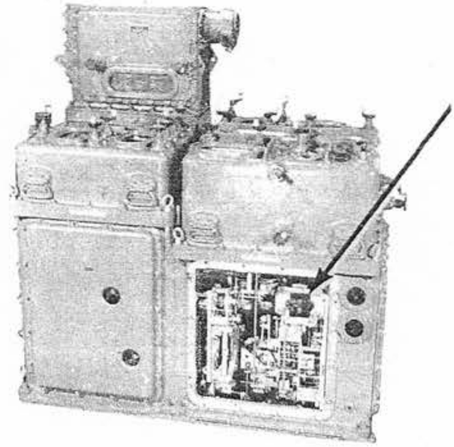
Reinstall the other mechanisms removed.

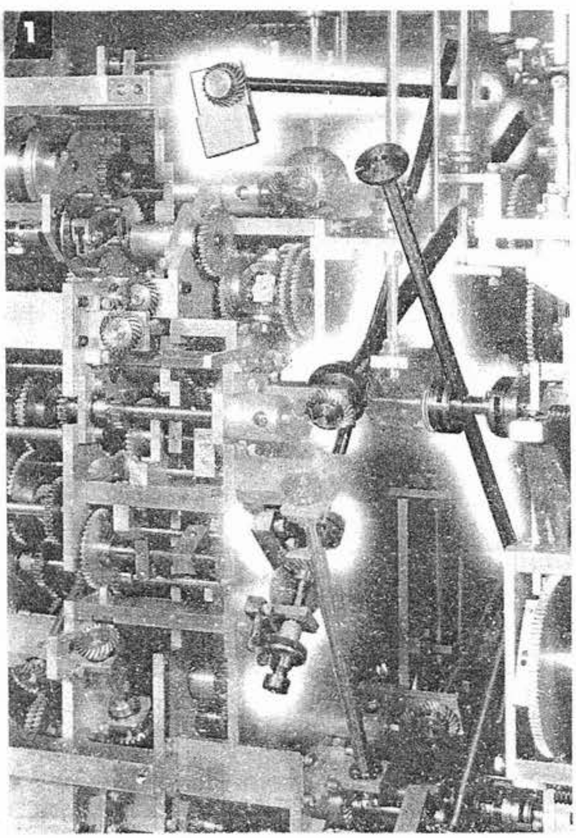
Readjust according to the instructions for reinstalling the horizontal wind component solver, page 723.

Run tests.

RANGE RATE CORRECTOR AND PREDICTION MULTIPLIERS



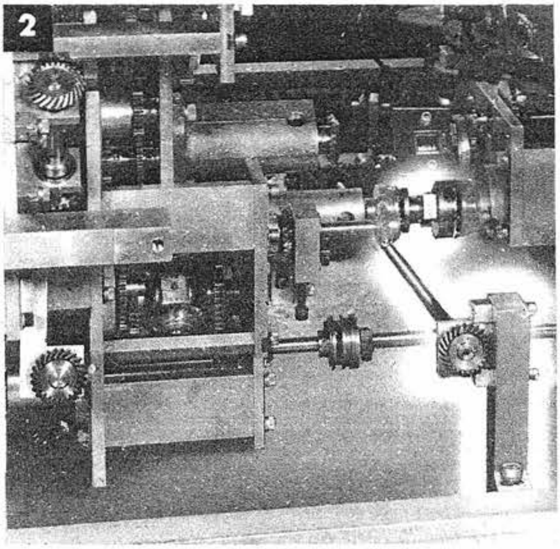


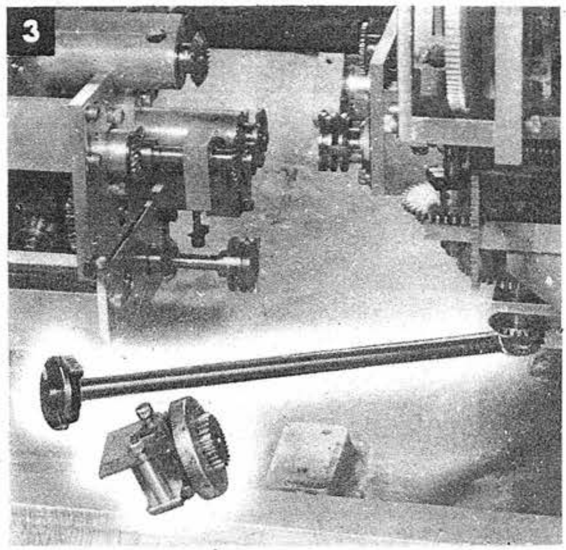


NOTE:
It is not practical to remove either of these mechanisms independently.

I.V., *Tg* Dial Group, page 714
WrD + *KRdBs* Follow-up, page 684
Prediction Multipliers Input Gearing, page 715
Horizontal Wind Component Solver, page 720
Elevation Wind Component Solver, page 724
Wind Component Solvers Output Gearing, page 726
Prediction Follow-up Mounting Plate, page 694

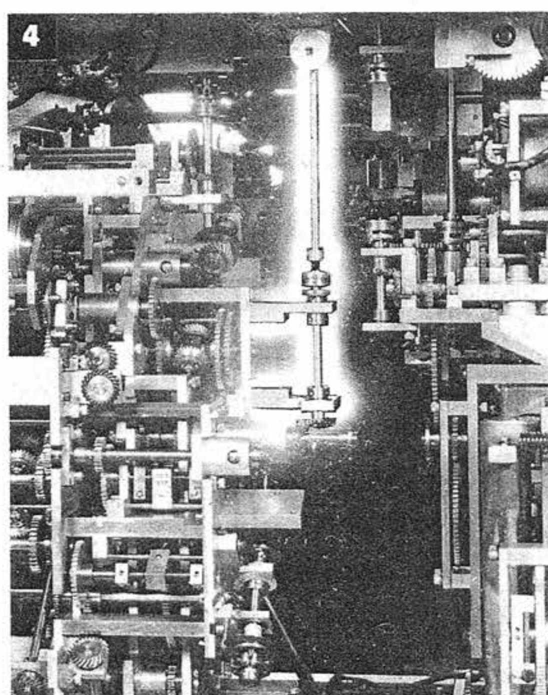
1 Remove the two screws securing the *Ds* shaft assembly. The other end of this assembly has been loosened in the removal of the prediction follow-up mounting plate.
Remove the locking springs from the short *RdBs* coupling shaft. Remove the shaft.
Remove the four screws securing the *Dj* friction shaft assembly. Remove the assembly.
Remove the four screws securing the *Vj* friction shaft assembly. Remove the assembly.
Remove the locking springs from the *Vj* coupling shaft. Remove the shaft.



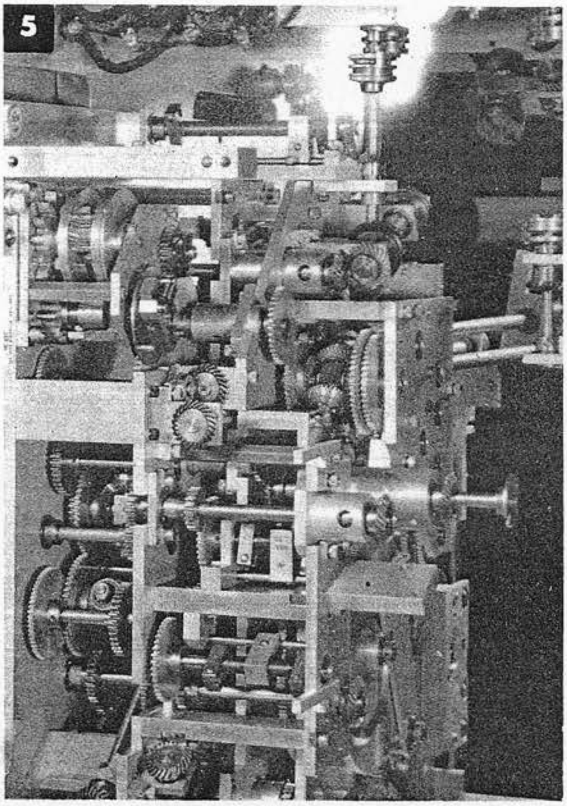


2 Remove the locking springs from the short *E* coupling shaft where clamp A-180 is mounted.
Remove the shaft.
Remove the four screws securing the long shaft assembly close to the bottom of the computer.
Remove the assembly.

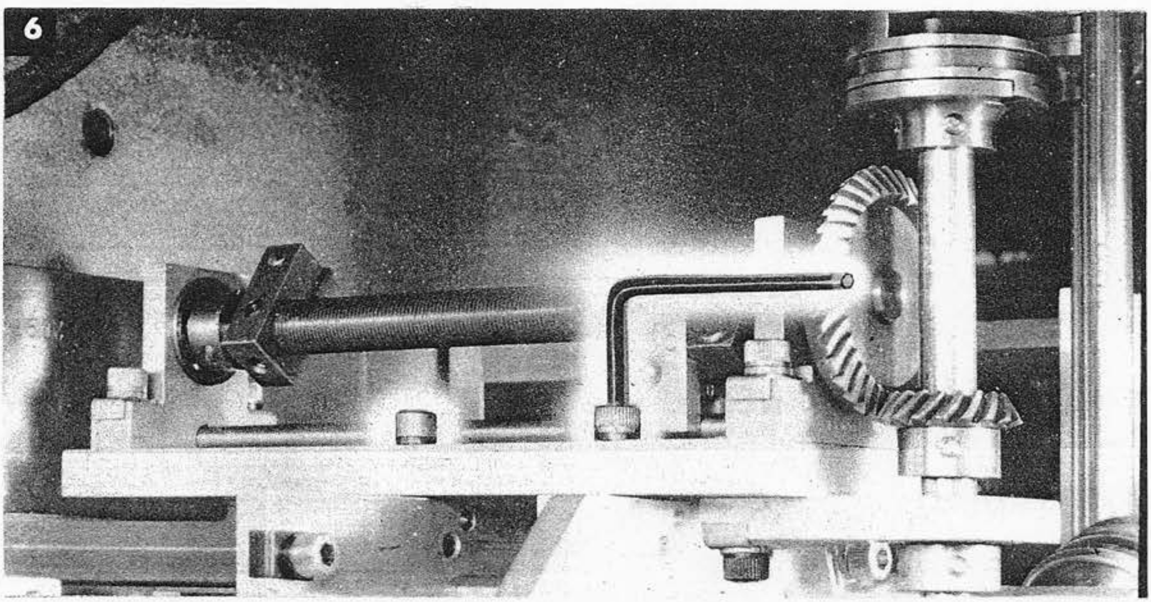
3 Remove the locking springs from the long coupling shaft where clamp A-183 is mounted.
Remove the shaft.
Remove the two screws securing the *E* check counter to its bracket. Remove the counter.



4 Remove the locking springs from the *RdBs* coupling shaft on which A-109 is mounted. Remove the shaft.
Remove the four screws securing the shaft assembly which connects with the coupling just below the one removed. Remove the shaft.



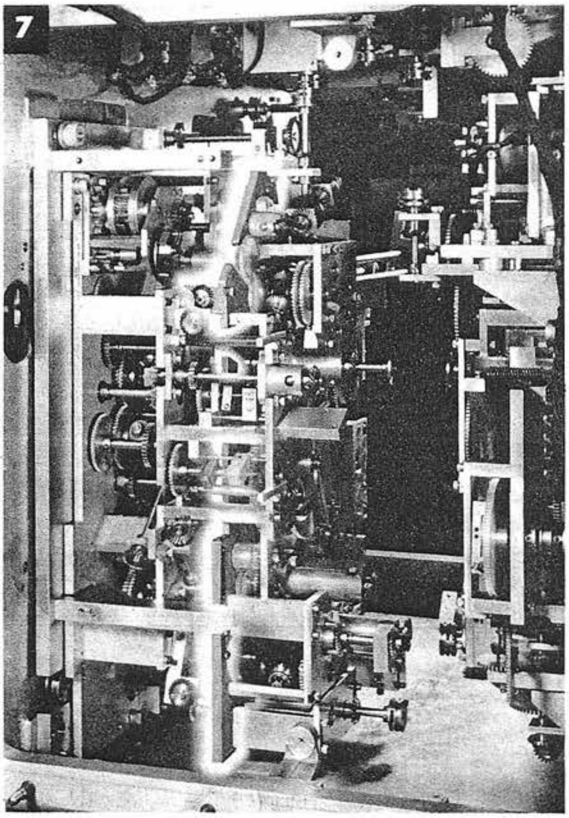
5 Remove the locking springs in the short cR coupling shaft next to the cR limit stop (L-10). Remove the shaft.



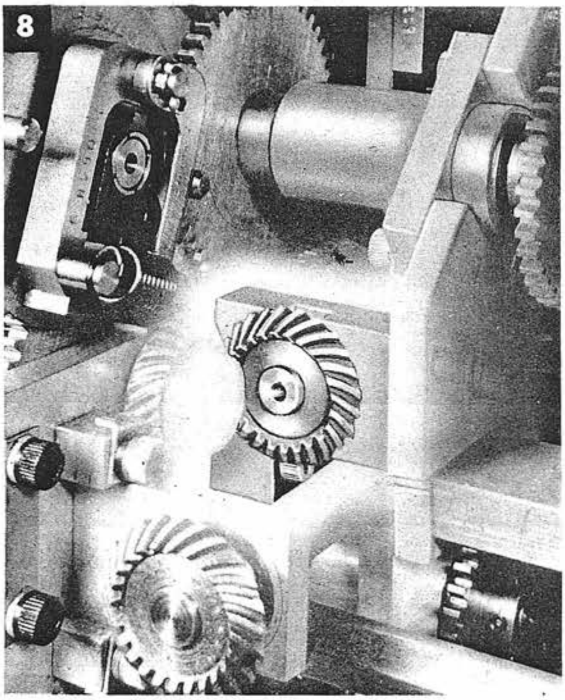
6 Remove the six screws securing the cR limit stop (L-10) mounting plate to the computer. Remove the limit stop and plate.
Remove the screws securing the hanger at the ballistic end of the $E2$ coupling shaft.

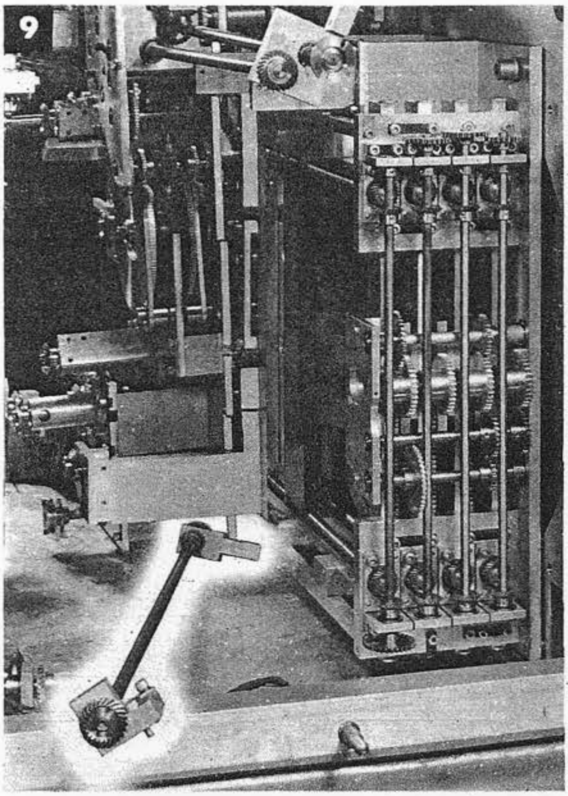
7 To remove either the range rate corrector or the prediction multiplier, both must be partially removed before either can be taken out.

Remove the screws securing the mounting plate for the range rate corrector. Work the dowels loose. Ease the mechanism out just far enough to gain access to the two screws securing the hanger for the long horizontal shaft behind it.

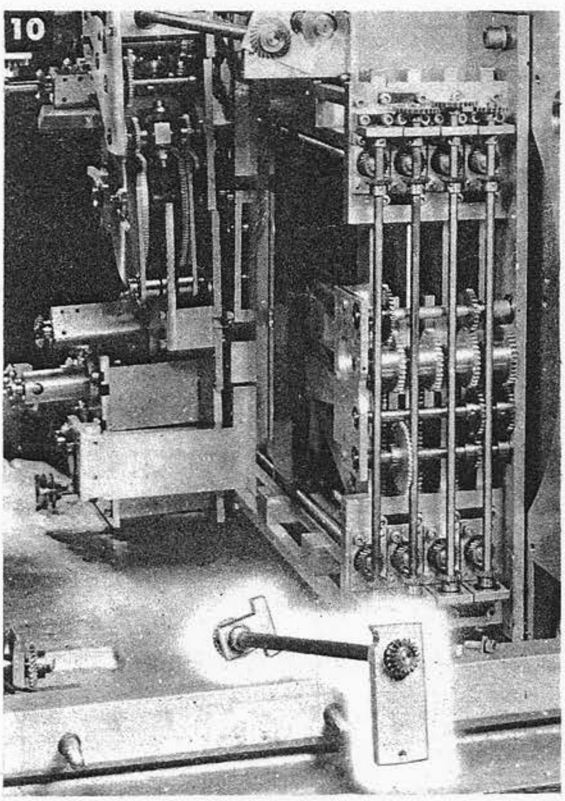


8 Remove the two screws securing this hanger.





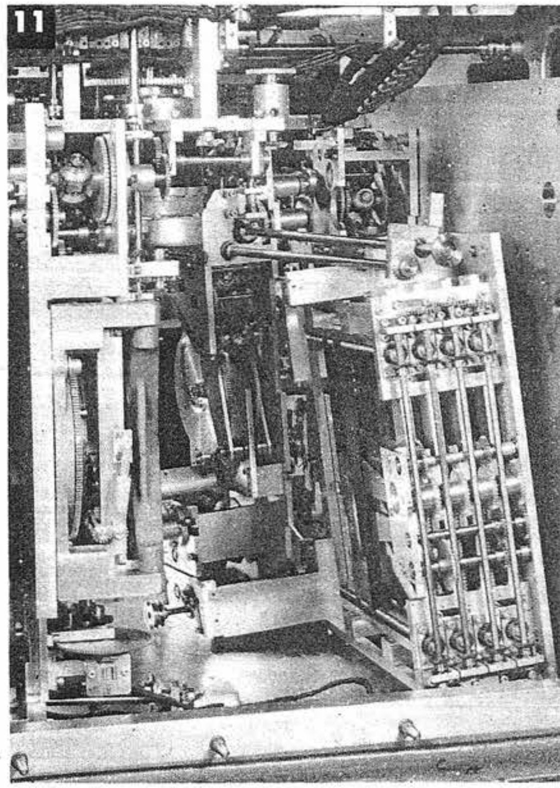
9 Remove the shaft from the left side of the computer.



10 Remove the screws from the short shaft assembly which connects the prediction multilier unit to the prediction output gearing. Remove the shaft assembly.

11 Back out the two screw dowels. Remove the screws securing the prediction multiplier unit.

Move the range rate corrector unit toward the back of the computer to allow removal of the prediction multiplier unit.



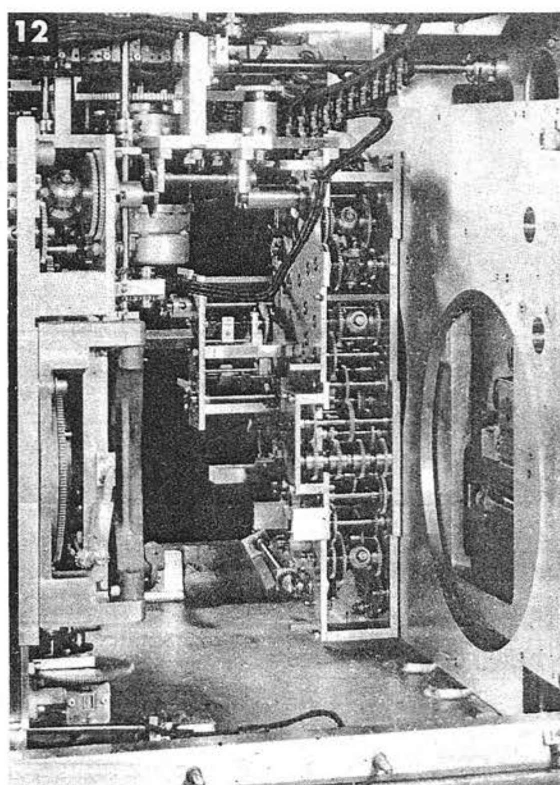
12 Remove both units from the left side of the computer.

To reinstall the range rate corrector and prediction multipliers, reverse the removal procedure.

Reinstall the other mechanism removed.

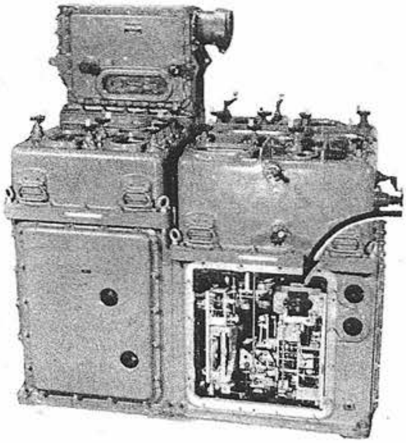
Readjust according to the instructions for reinstalling the horizontal wind component solver, page 723.

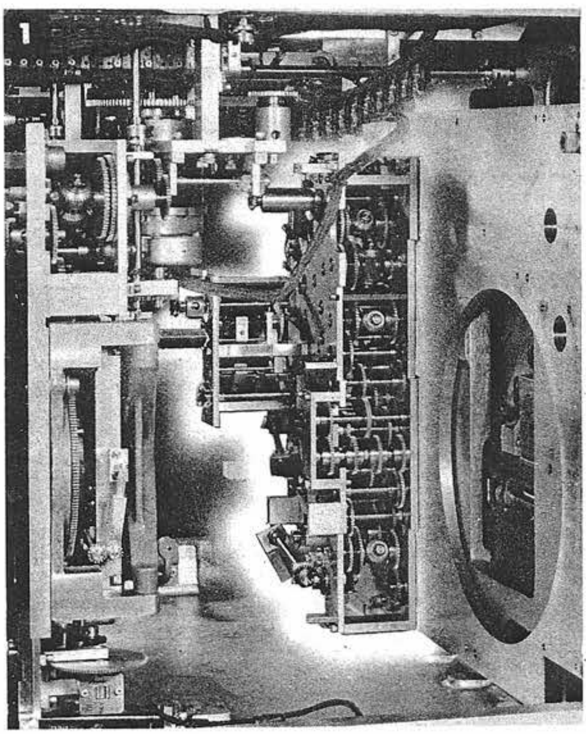
Run all tests.



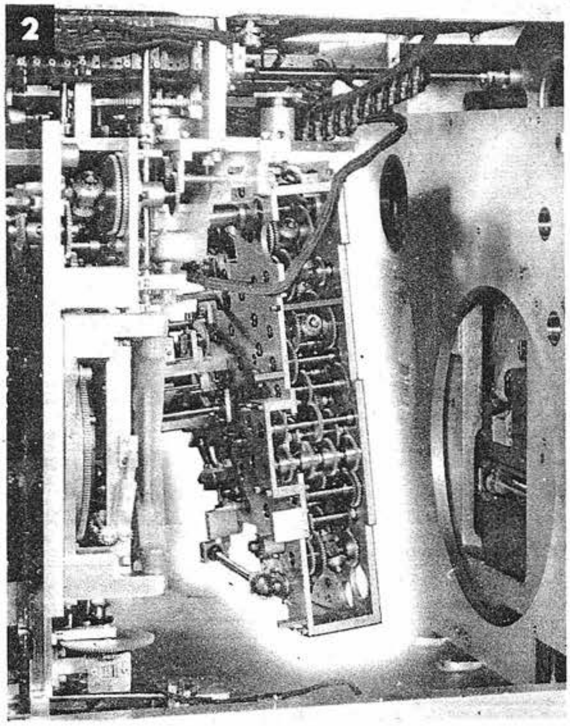
PREDICTION MULTIPLIERS OUTPUT GEARING

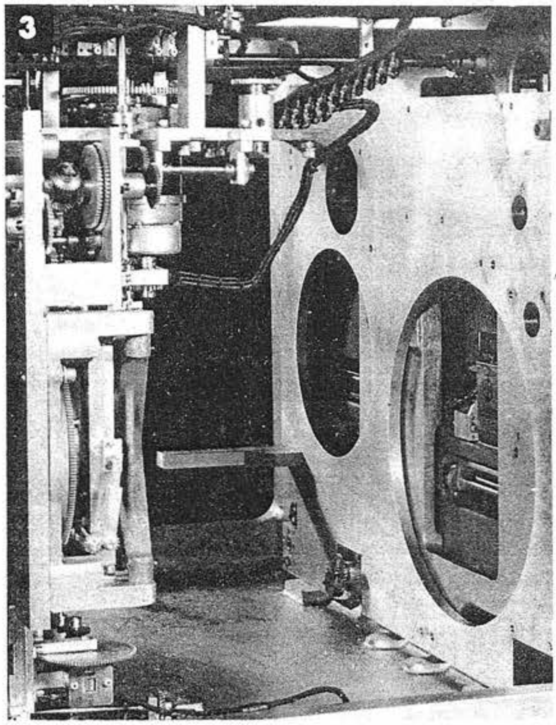
I.V., *Tg* Dial Group, page 714
WrD + *KRdBs* Follow-up, page 684
Prediction Multipliers Input Gearing, page 715
Horizontal Wind Component Solver, page 720
Elevation Wind Component Solver, page 724
Wind Component Solvers Output Gearing, page 726
Prediction Follow-up Mounting Plate, page 694
E2 Intermittent Drive, page 696
Range Rate Corrector and Prediction Multipliers, page 730





1 Remove the three screws securing the mechanism.





2 Tilt the mechanism to clear the surrounding gearing.

3 Remove the mechanism from the left side of the computer.

To reinstall the gearing unit, reverse the removal procedure.

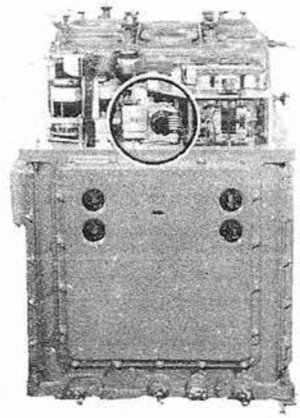
Reinstall the other mechanisms removed.

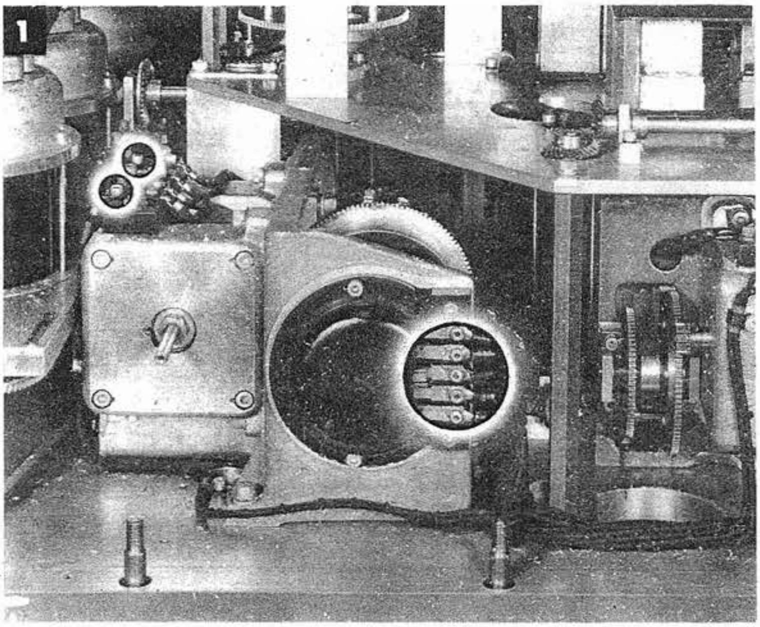
Readjust according to the instructions for reinstalling the horizontal wind component solver, page 723

Run all tests.

So RECEIVER

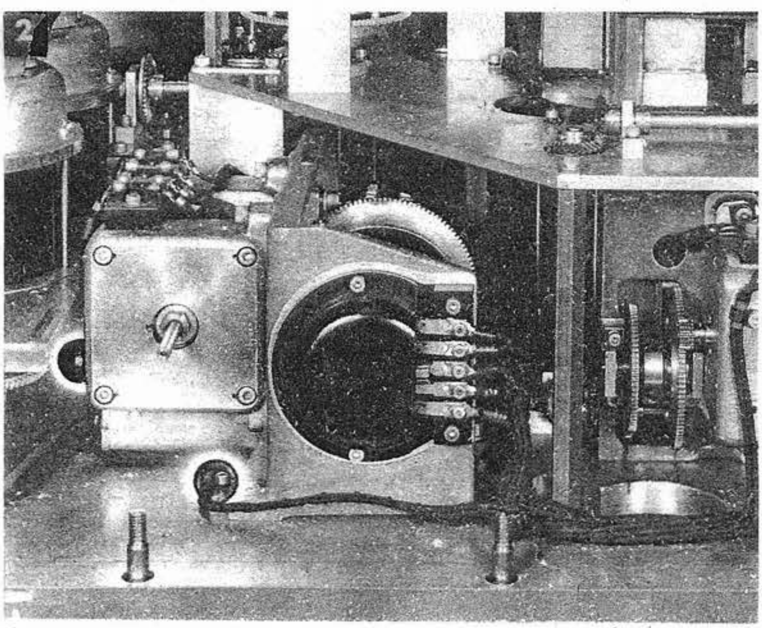
Star Shell Computer, page 804





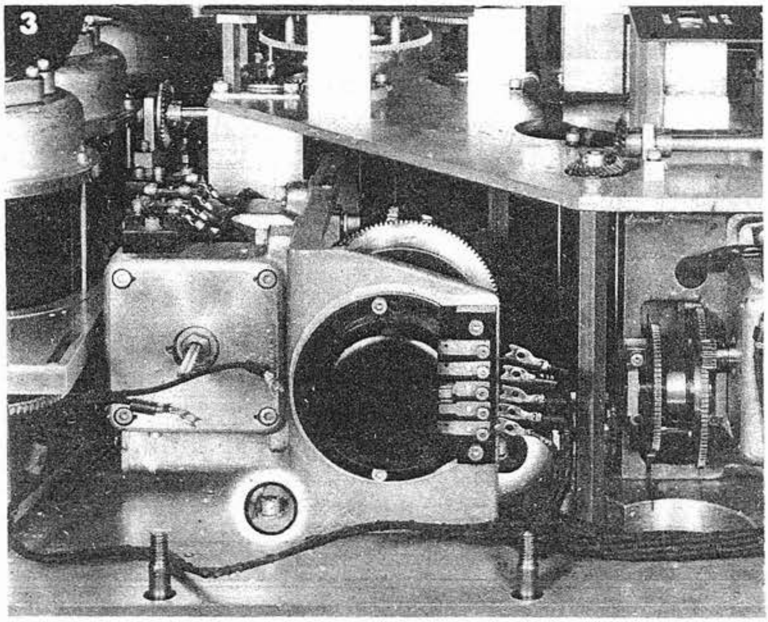
1 Remove the two screws connecting cable leads Y and YY to the servo terminal block.

Remove the five screws connecting the cable leads to the synchro terminal block.

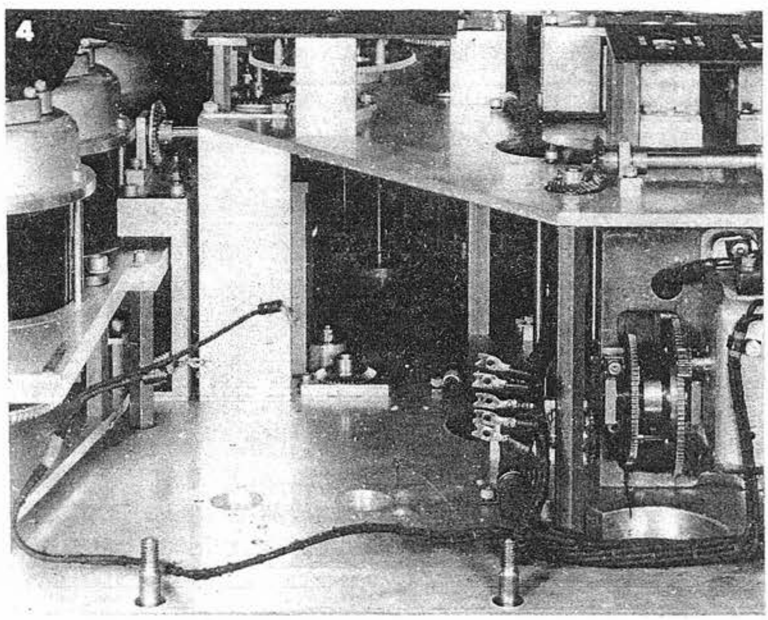


2 Remove the two screws securing the cable clamps near the servo motor.

3 Remove the three screws securing the receiver. Remove the rear screw through the access hole in the upper plate.



4 Remove the receiver.



To reinstall the *So* receiver, reverse the removal procedure.

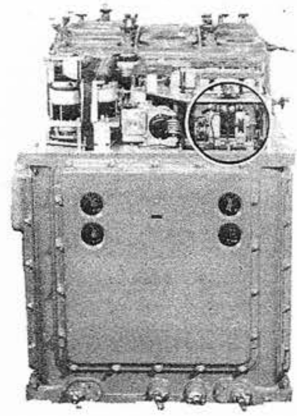
Readjust A-212.

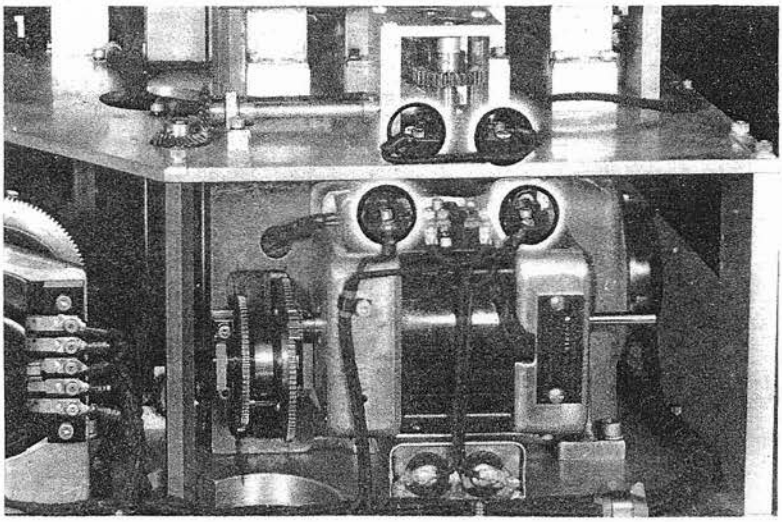
Run transmission tests.

Reinstall the star shell computer, and test.

Rj RECEIVER

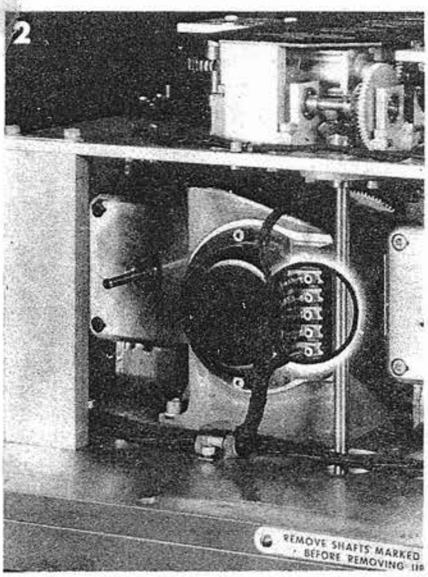
Star Shell Computer, page 804

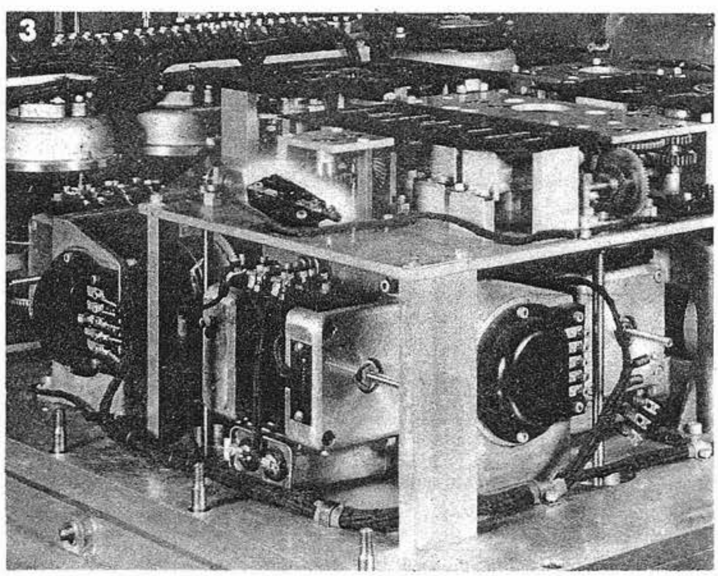




1 Remove the two screws connecting cable leads **X** and **XX** to the servo terminal block.

Remove the two screws securing the push switch above the servo motor.

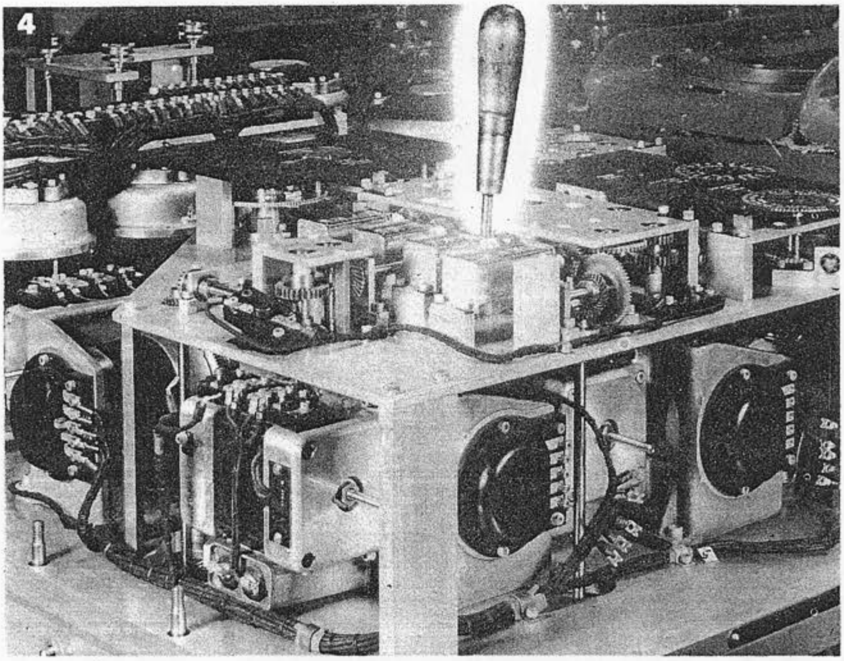




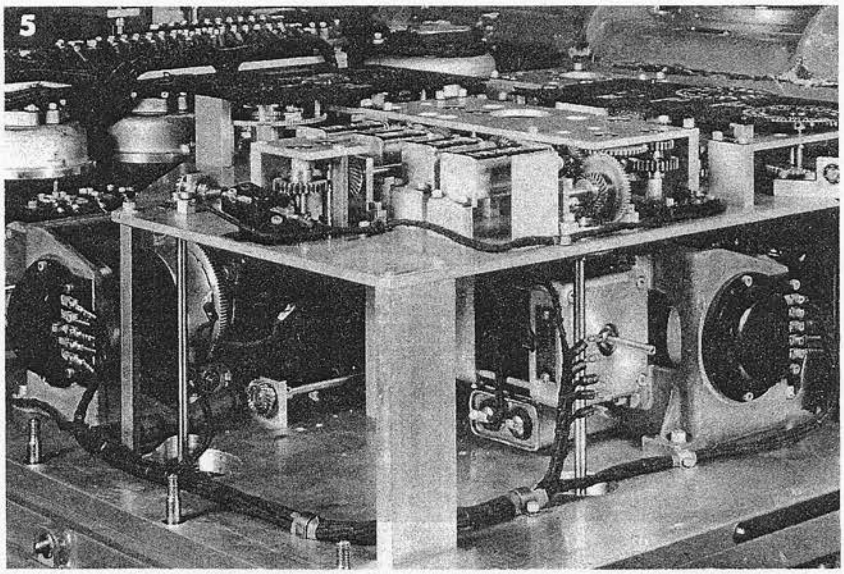
2 Remove the five screws connecting the cable leads to the synchro terminal block.

3 Push the switch up through the plate.

4 To reach the access holes for the rear screws, remove the mask over the counters above the receiver.
Remove the three screws securing the receiver.



5 Remove the receiver by tilting it to clear the stud at the rear edge of the mounting plate.



To reinstall the *Rj* receiver, reverse the removal procedure.

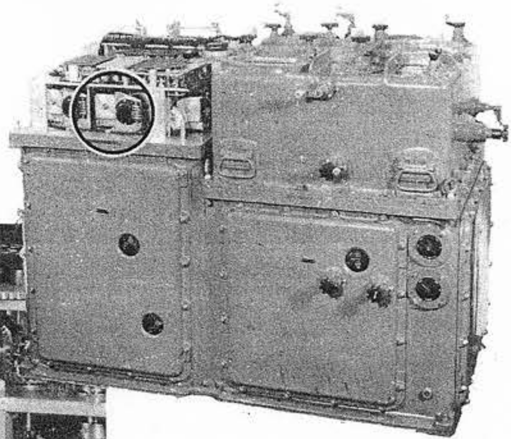
Readjust clamp A-88.

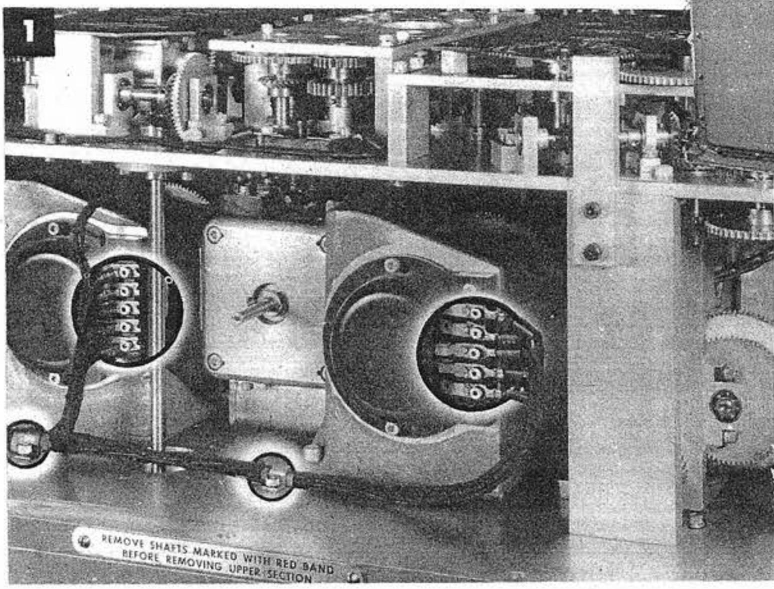
Run transmission tests.

Reinstall the star shell computer, and readjust it to the instrument.

V_j RECEIVER

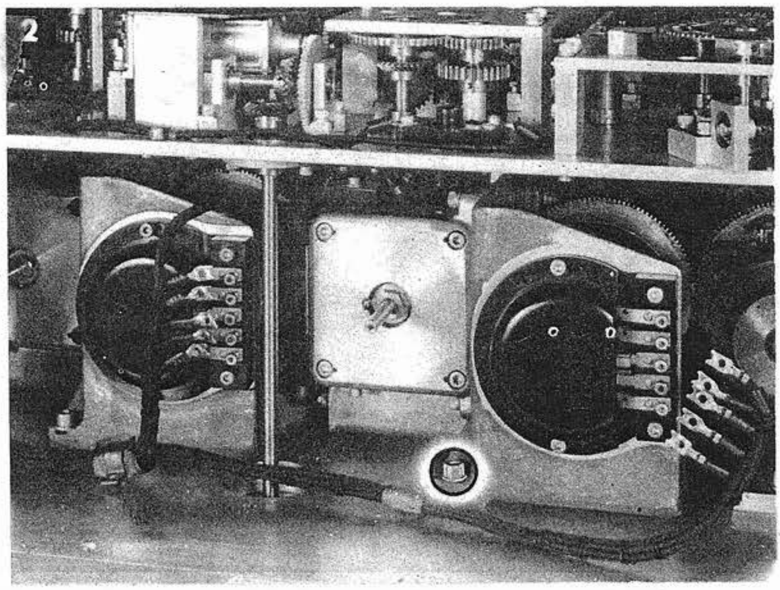
Star Shell Computer, page 804





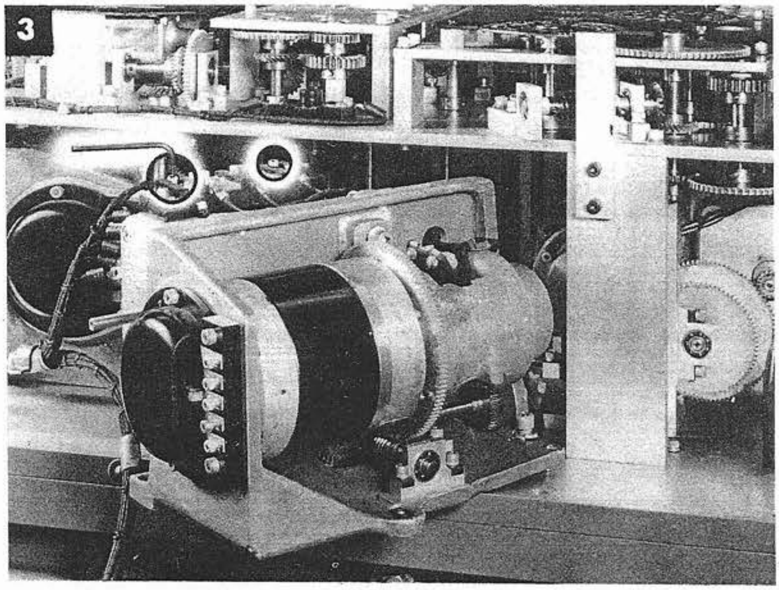
1 Remove the ten screws connecting the cable leads to the synchro terminal blocks of the *Rj* and the *Vj* receivers.

Remove the two screws securing the two cable clamps near the receivers.

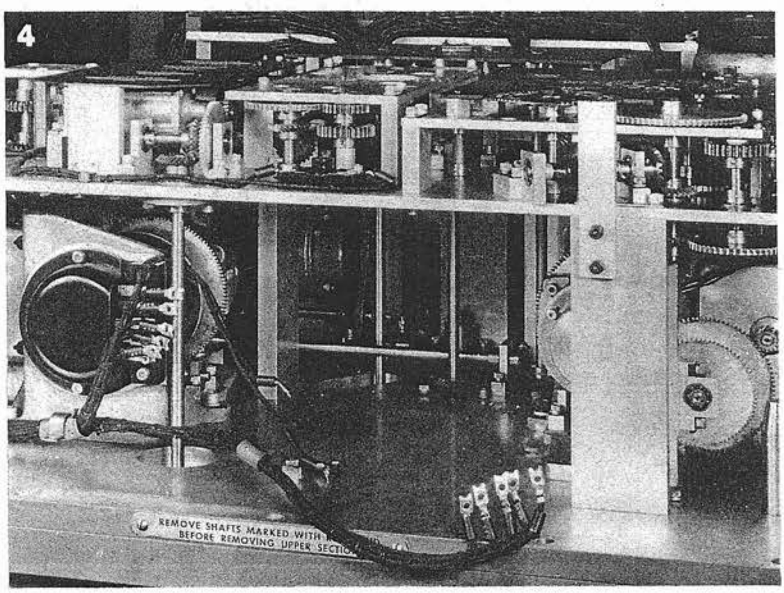


2 Remove the three screws securing the receiver. Reach through the access hole in the upper plate to remove the rear screw.

3 Slide the receiver out to reach the two screws connecting cable leads W and WW to the servo terminal block. Remove the two screws.



4 Remove the receiver.



To reinstall the *Vj* receiver, reverse the removal procedure.

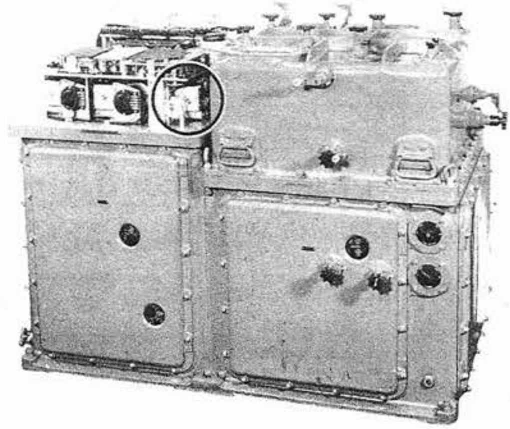
Readjust clamp A-87.

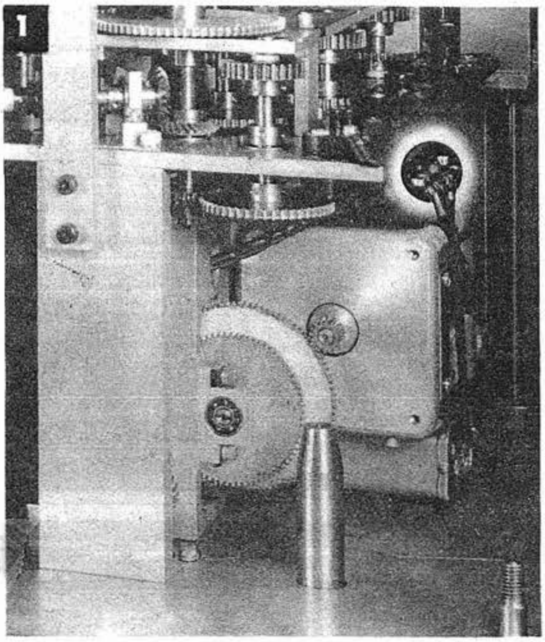
Run transmission tests.

Reinstall the star shell computer, and readjust it to the instrument.

Dj RECEIVER

Star Shell Computer, page 804
Vj Receiver, page 742

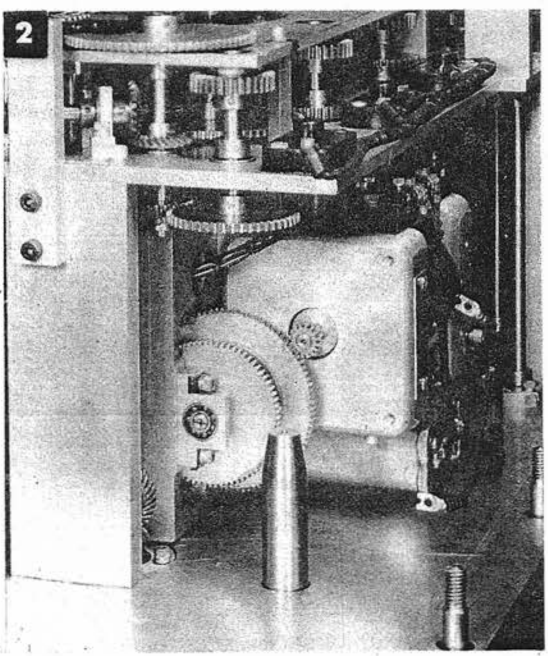




1 Remove the two screws connecting cable leads V and VV to the servo terminal block.

Loosen the screw securing the cable clamp to the servo motor.

Free the cable.

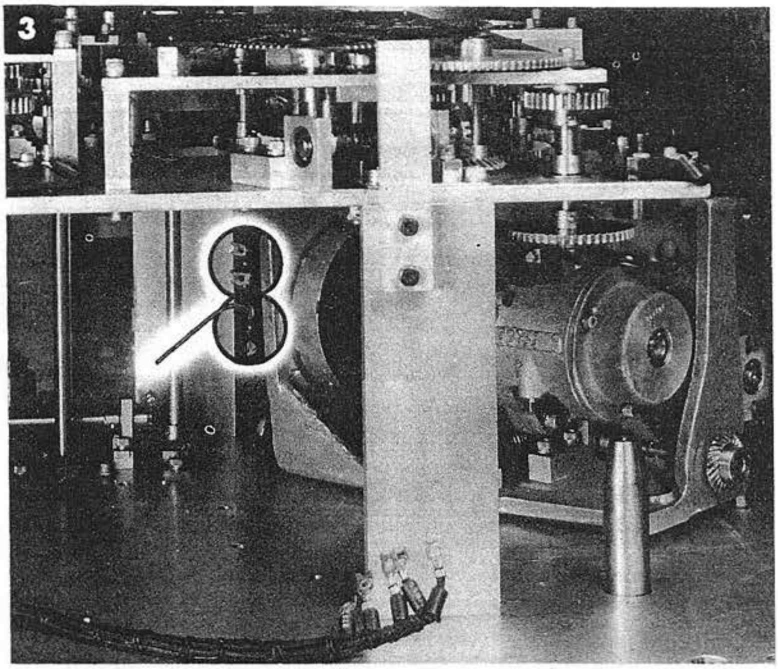


2 Remove the three screws securing the receiver. Reach through the access hole in the plate above to remove the rear screw.

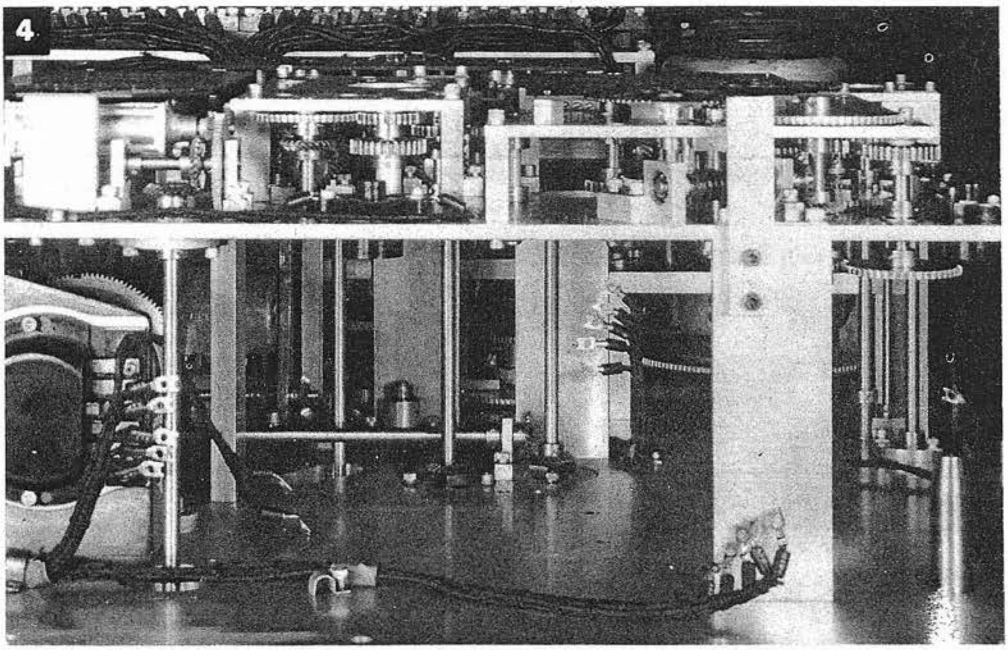
Loosen the screw securing the cable clamp behind the receiver.

Free the cable.

3 Turn the receiver to reach the screws connecting the cable leads to the synchro terminal block. Remove the five screws.



4 Remove the *Dj* receiver through the opening made by the removal of the *Vj* receiver.



To reinstall the *Dj* receiver, reverse the removal procedure.

Reinstall the *Vj* receiver.

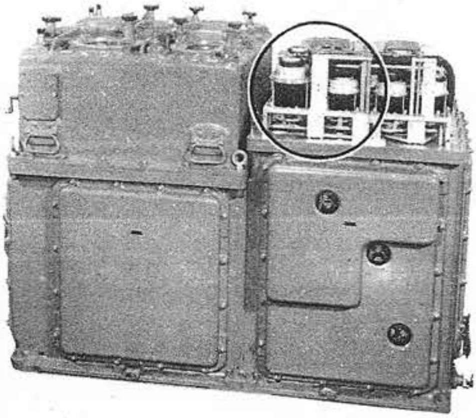
Readjust clamps A-86 and A-87.

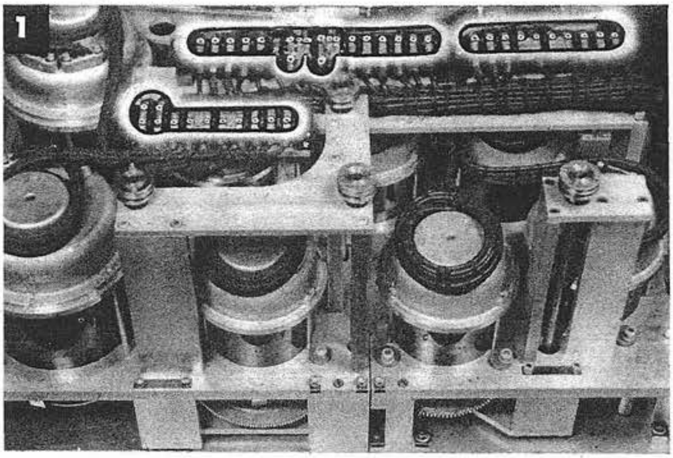
Run transmission tests.

Reinstall the star shell computer, and readjust it to the instrument.

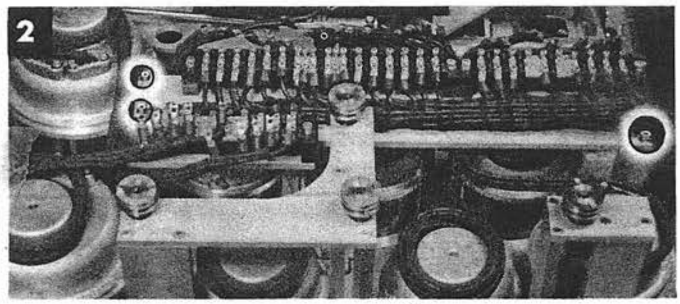
FUZE AND Ds TRANSMITTER GROUP

Star Shell Computer, page 804

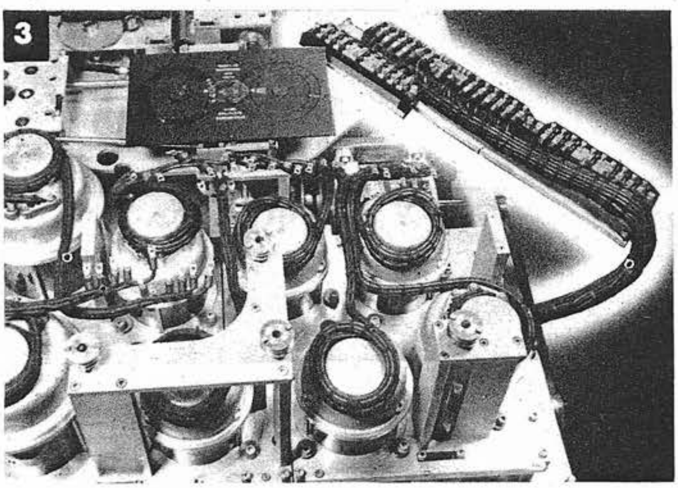




1 Remove the screws connecting all transmitter cable leads to the terminal blocks above the transmitters. Free the cable.

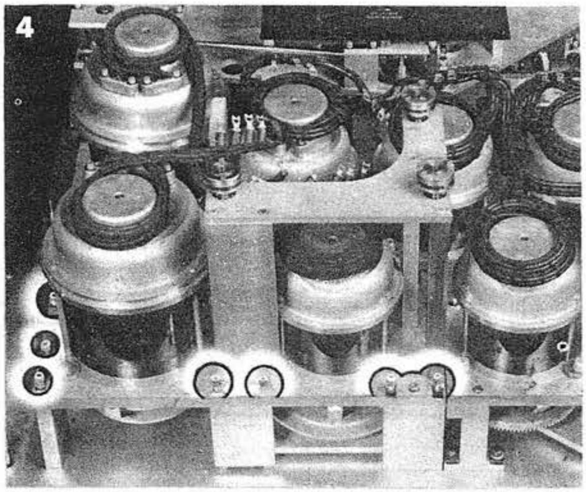


2 Remove the four screws securing the mounting plate for the terminal blocks.

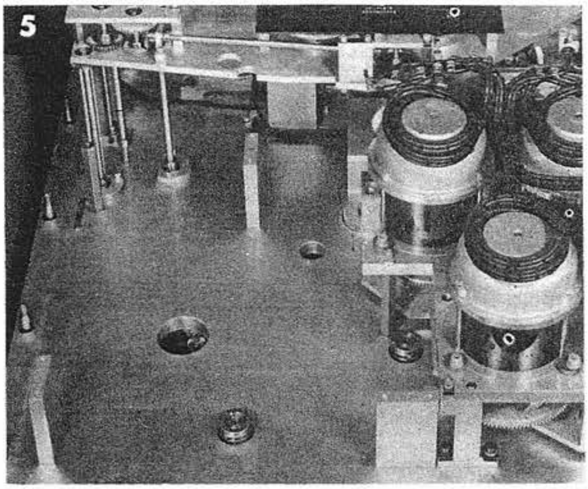


3 Push the terminal block and the mounting plate aside.

4 Back out the two screw dowels and all the screws securing the transmitter group mounting plate.



5 Lift the transmitter group straight up and remove it.



To reinstall the transmitter group, reverse the removal procedure.

Check clamp A-213.

Readjust clamps A-94, A-89, and A-96.

Check clamps A-66 and A-67.

Readjust clamps A-93 and A-77.

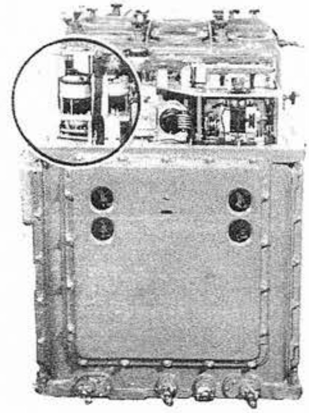
Run transmission tests.

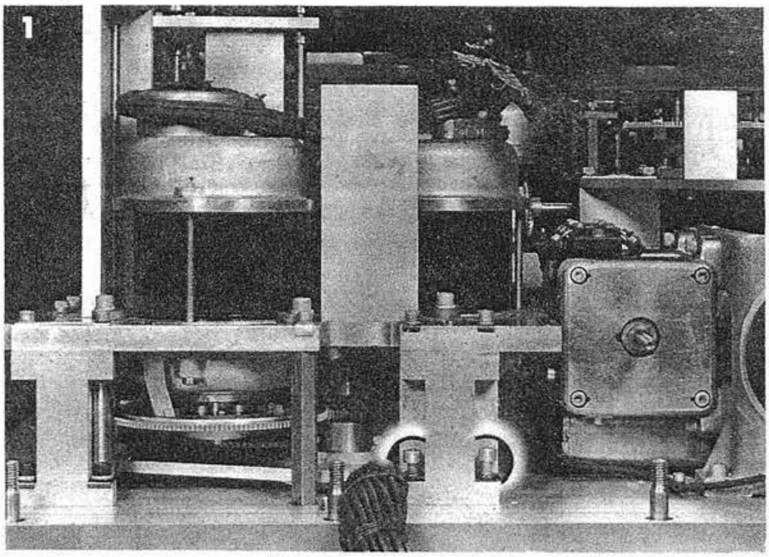
Reinstall the star shell computer, and readjust it to the instrument.

CAUTION
If any one of the synchros has been removed, it is necessary to make the following adjustment to the reinstalled synchro before reinstalling the complete group: Set the rotor of the reinstalled synchro on electrical zero. Loosen the three screws holding the engraved plate on the rotor gear. Slip the plate to match the fixed index of the unit. Tighten the screws.

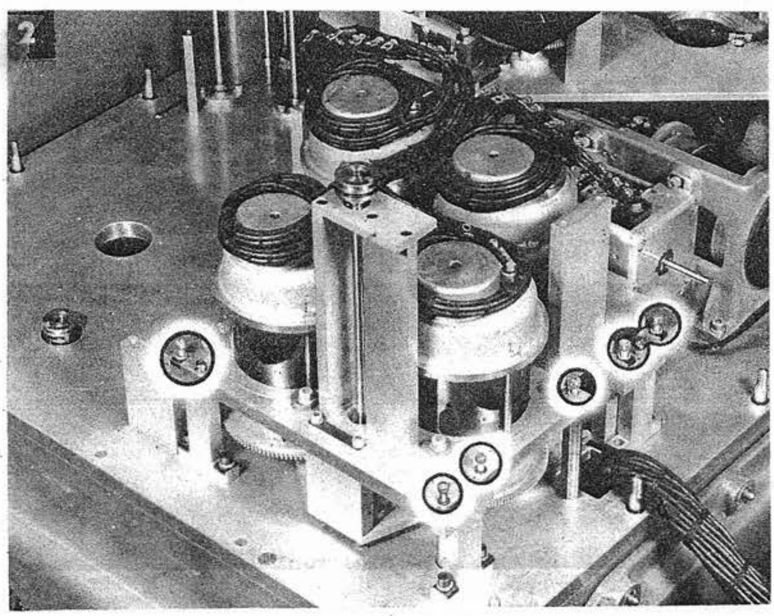
Vs, Ds TRANSMITTER GROUP

Fuze and *Ds* Transmitter Group, page 746



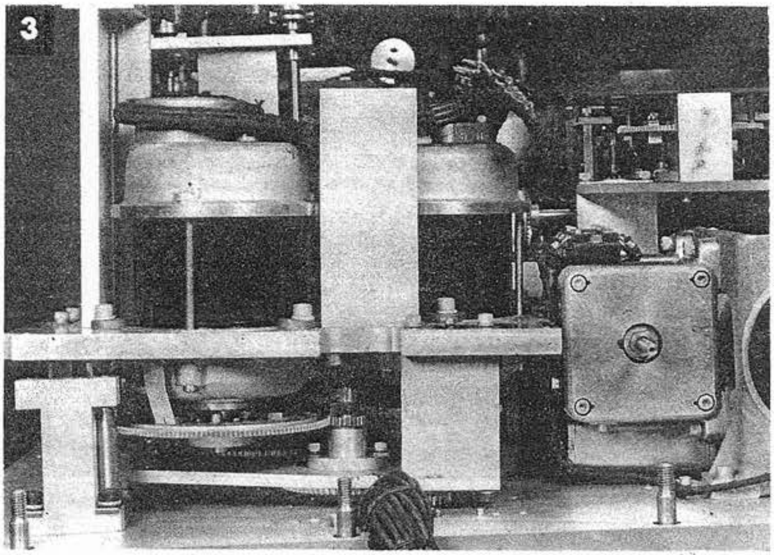


1 Remove the two screws in the base of the supporting hanger next to the cable.

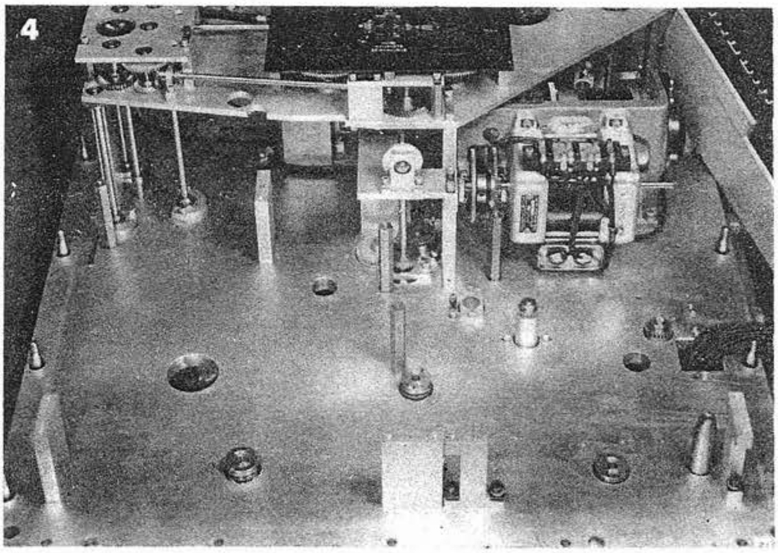


2 Remove all the screws securing the transmitter group mounting plate. Back out the two screw dowels.

3 Lift the plate slightly and remove the supporting hanger next to the cable. Unscrew the hexagonal post.



4 Lift the transmitter group toward the left rear corner of the computer to clear all interference. Remove the transmitter group.



To reinstall the transmitter group, reverse the removal procedure.

Follow the readjustment procedure in the instructions for the reinstallation of the Fuze and *Ds* transmitter group. The caution at the end of that procedure also applies here.

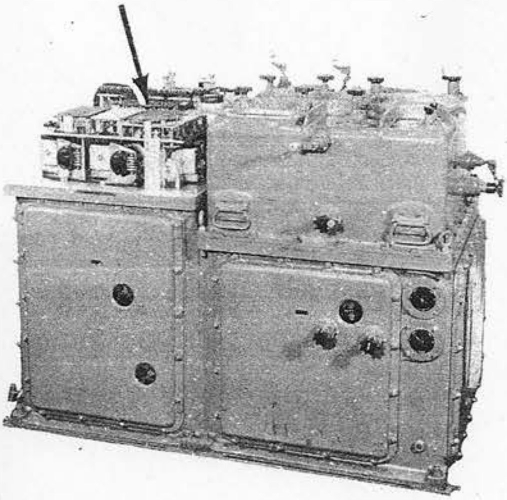
Check clamp A-214.

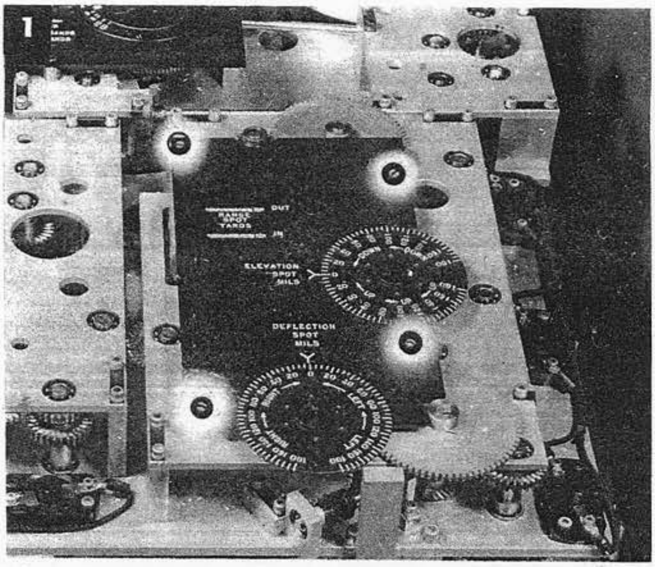
Readjust clamps A-95, A-55, A-97, A-69, and A-96.

Check clamp A-66.

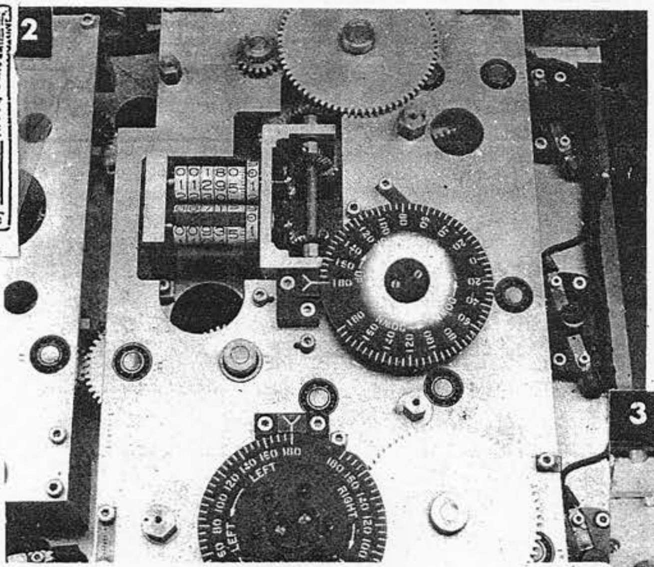
Rj COUNTER ASSEMBLY

Star Shell Computer, page 804



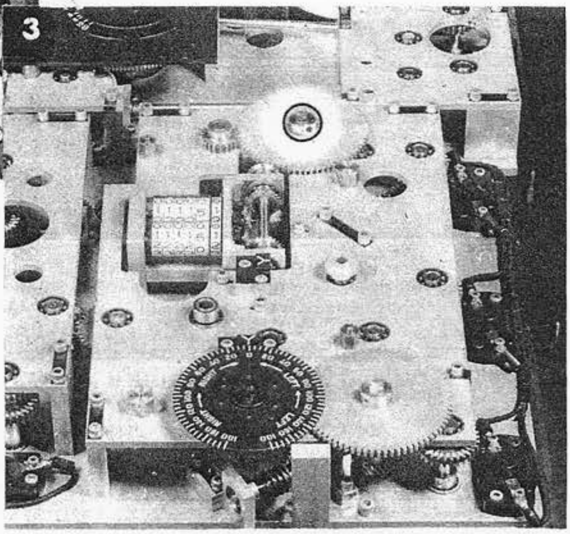


1 Remove the four screws securing the mask over the counter assembly.



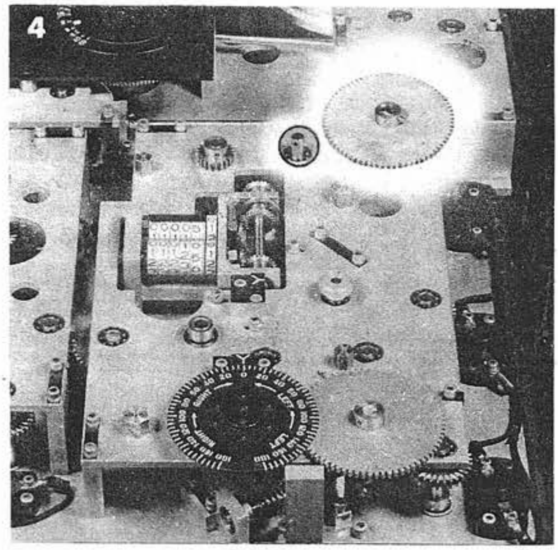
2 Remove the Vj dial clamp. Remove the dial.

3 Unpin the large gear next to the counter assembly.

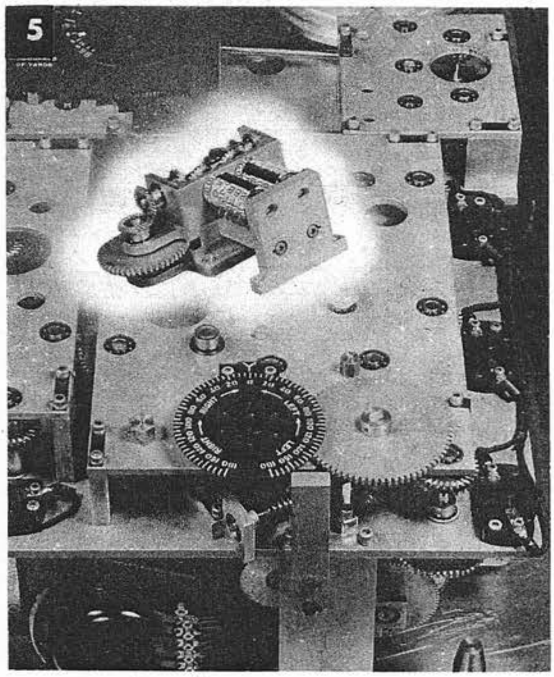


4 Remove the gear from the shaft.

Remove the five screws securing the counter assembly casting.

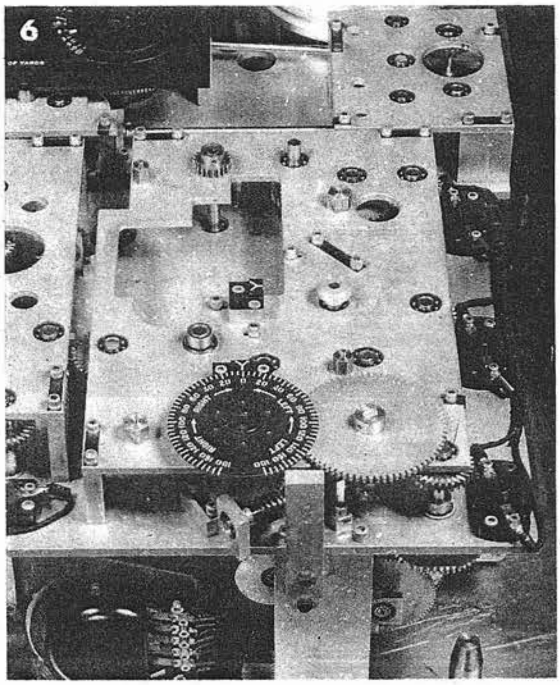


5 Tilt the assembly to clear the plate and surrounding gearing.



6 Remove the counter assembly.

To reinstall the *Rj* counter assembly, reverse the removal procedure.



Readjust clamps A-234 and A-235.

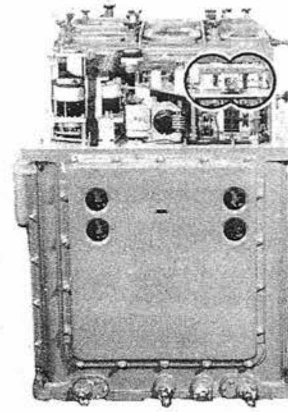
Check clamp A-88.

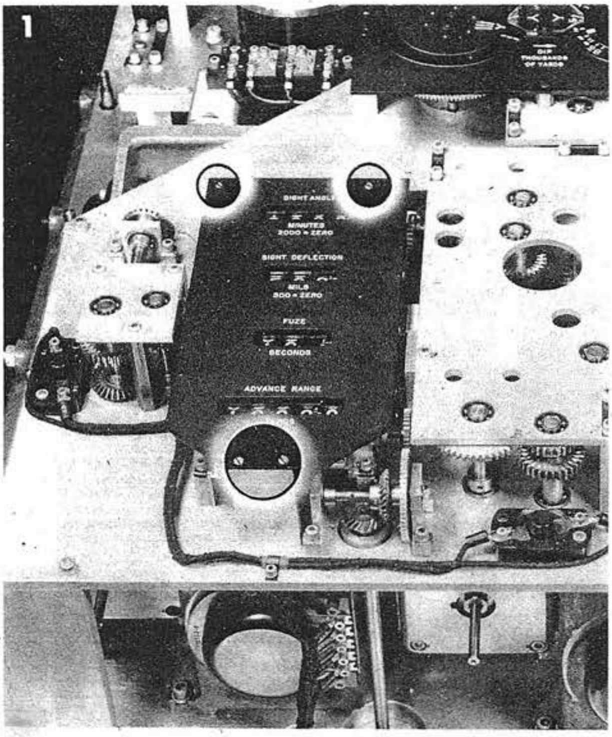
Readjust clamp A-501.

Check clamp A-87.

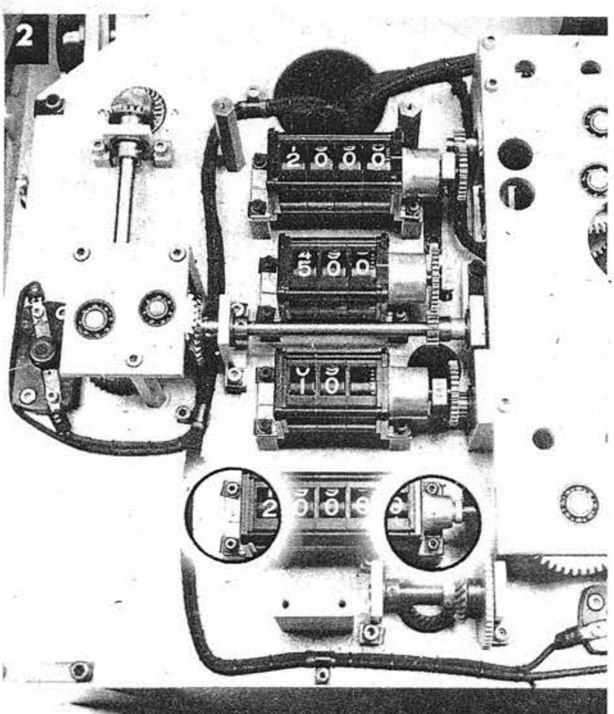
Ds, Vs, FUZE, AND R2 COUNTERS

Star Shell Computer, page 804





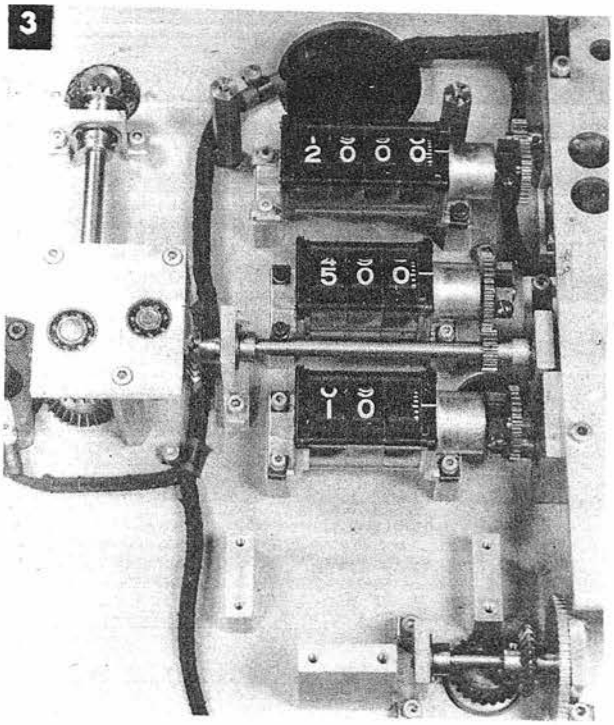
1 Remove the four screws securing mask. Remove the mask.



2 Remove the four screws securing a counter.

3 Remove the counter.

3



To reinstall a counter, reverse the removal procedure.

There is a different readjustment procedure for each counter, as follows:

Ds counter: Readjust clamp A-94 in accordance with the instructions for readjusting clamp A-89. Use A-94 to match the *Ds* indicating counter to the *Ds* master counter.

Check clamp A-96.

Vs counter: Readjust clamp A-95 in accordance with the instructions for readjusting clamp A-184. Use A-95 to match the *Vs* indicating counter to the *Vs* master counter.

Check clamp A-97.

R2 counter: Readjust clamps A-92 and A-18 in the star shell computer.

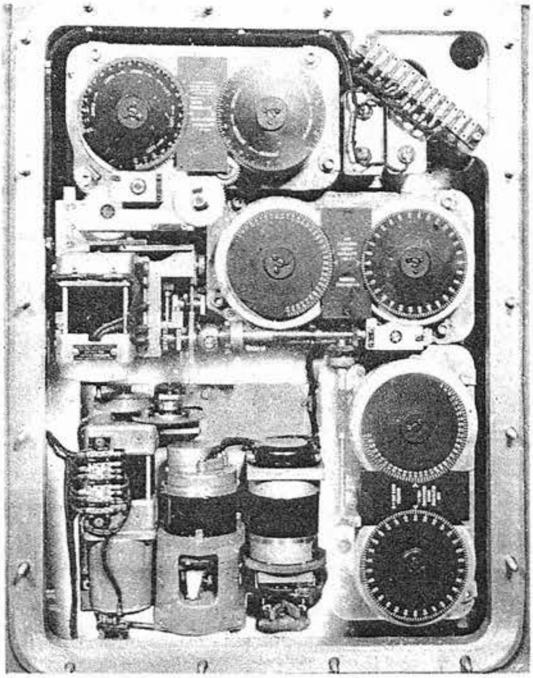
Fuze counter: Readjust clamp A-93 in accordance with the instructions for readjusting clamp A-77. Use A-93 to match the fuze indicating counter to the fuze master counter in the ballistic section.

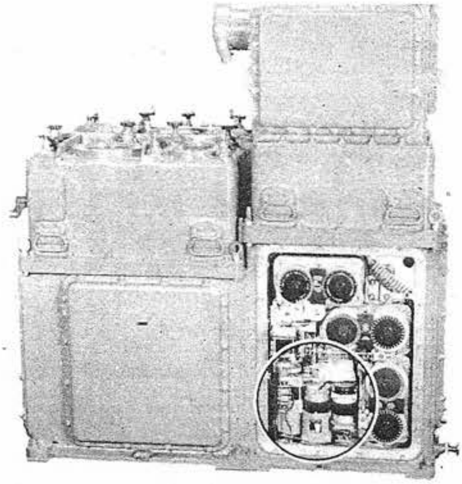
Check fuze transmission.

Corrector Unit

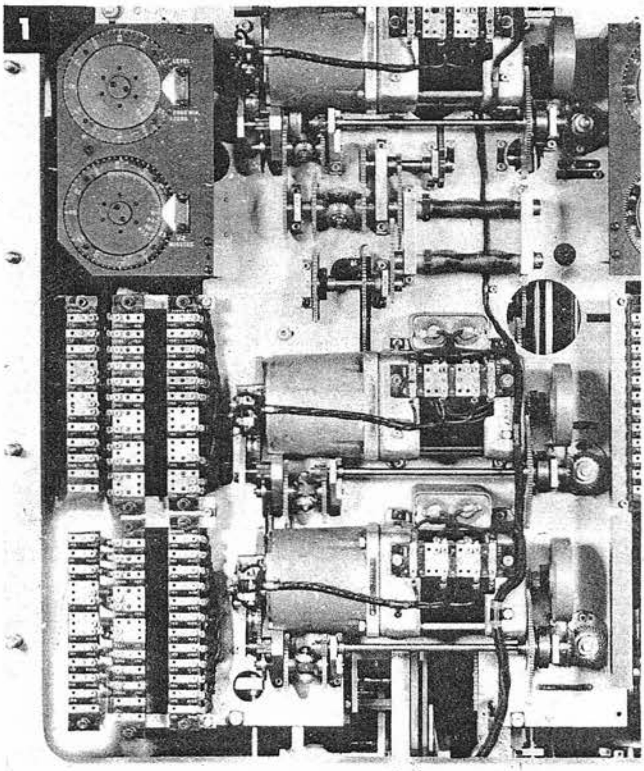
This unit includes the trunnion tilt section, the deck tilt section, and the parallax section, as well as the Eb and $B'r$ receivers, the $E'g$ and $B'gr$ transmitters, and the $B'r$ local control follow-up.

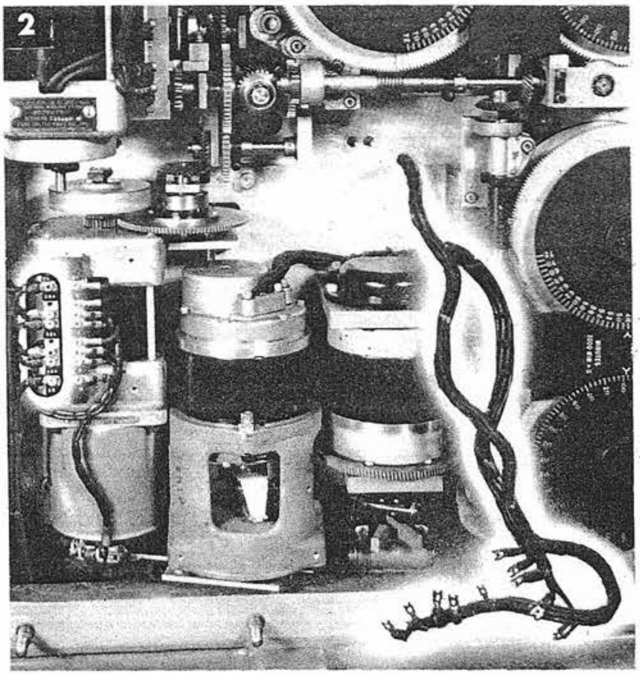
Eb RECEIVER



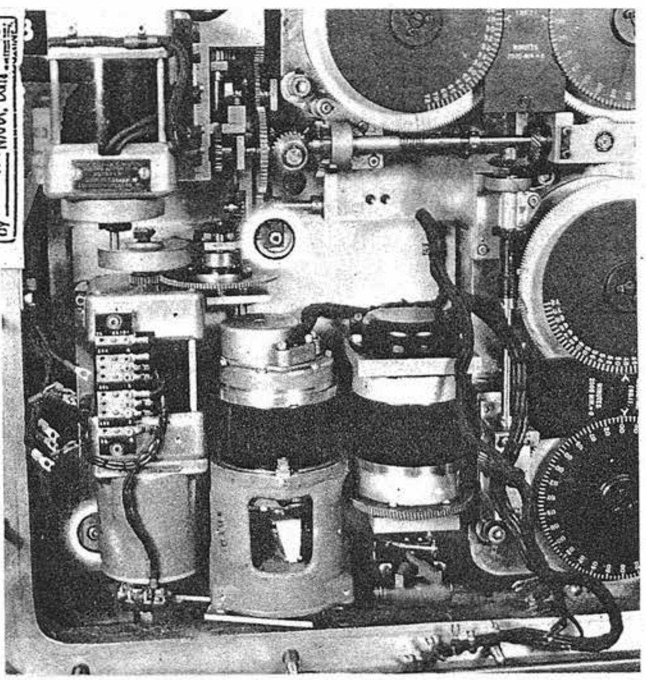


1 Remove the ten screws connecting the cable leads to the terminal block under the rear cover.

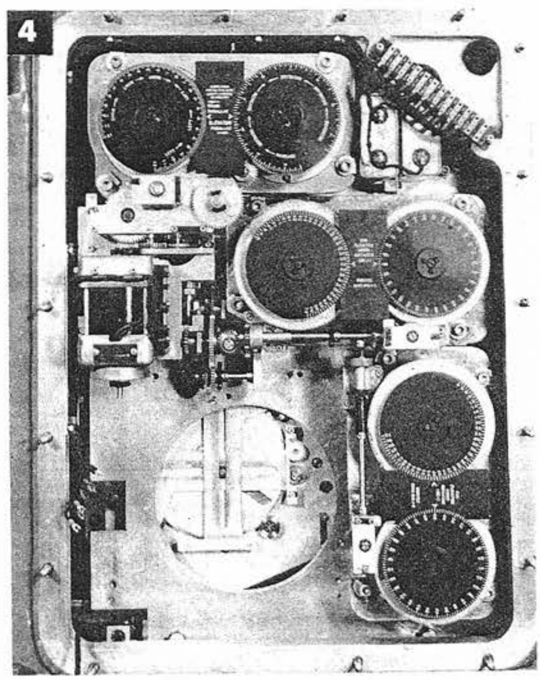




2 Pull the cable through to the receiver side of the instrument. Remove the screws connecting the external leads to the terminal block on the servo motor.



3 Remove the three screws securing the mechanism. Carefully free the dowels.



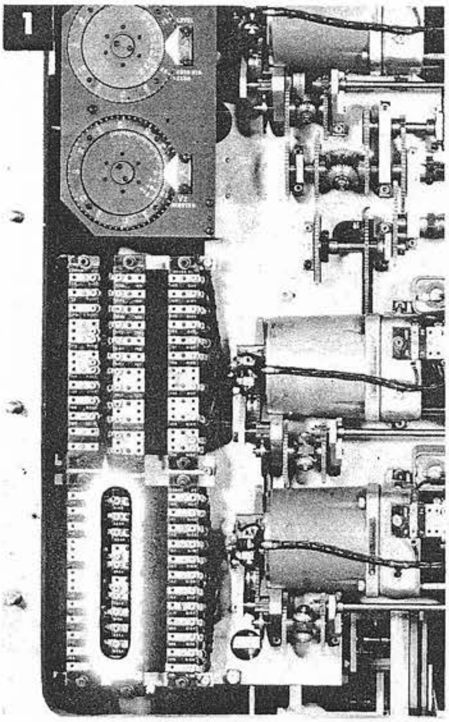
4 Remove the receiver.

To reinstall the *Eb* receiver, reverse the removal procedure.

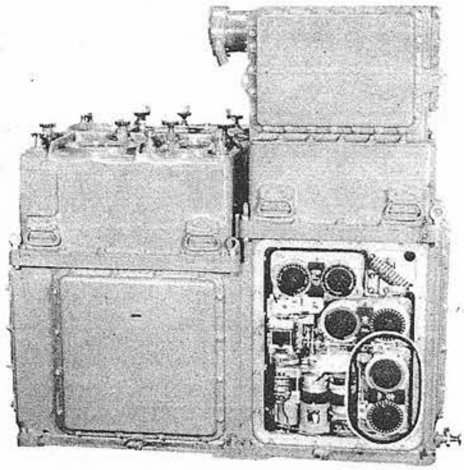
Readjust clamp A-50.

Run tests.

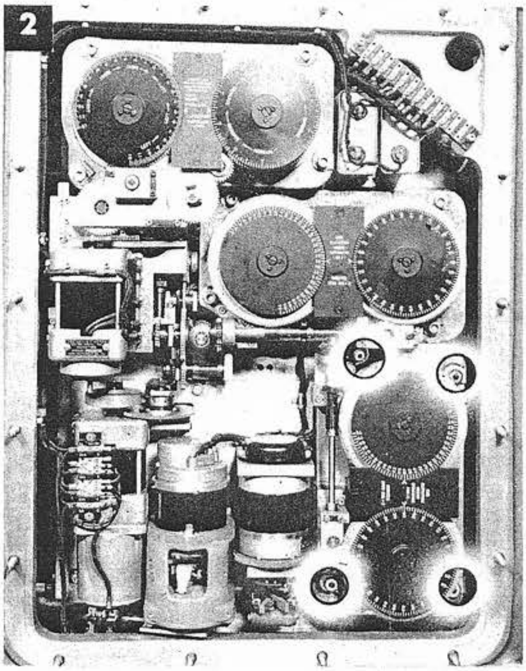
 Table of Contents



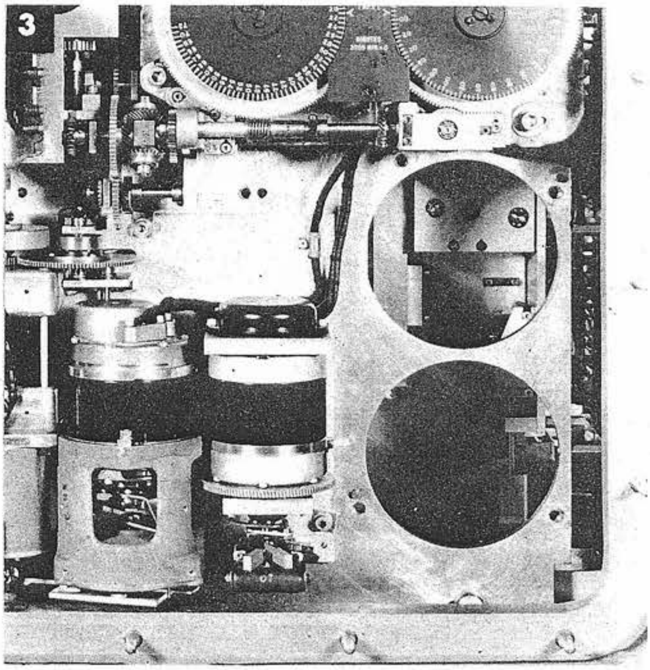
E'g INDICATING TRANSMITTERS



1 Remove the ten screws connecting the transmitter cable leads to the terminal block under the rear cover.



2 Remove the four screws securing the transmitters.

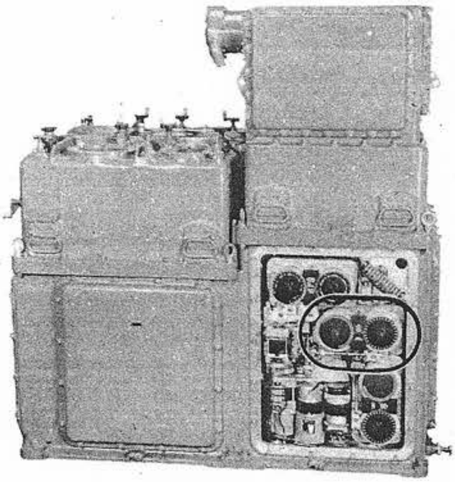


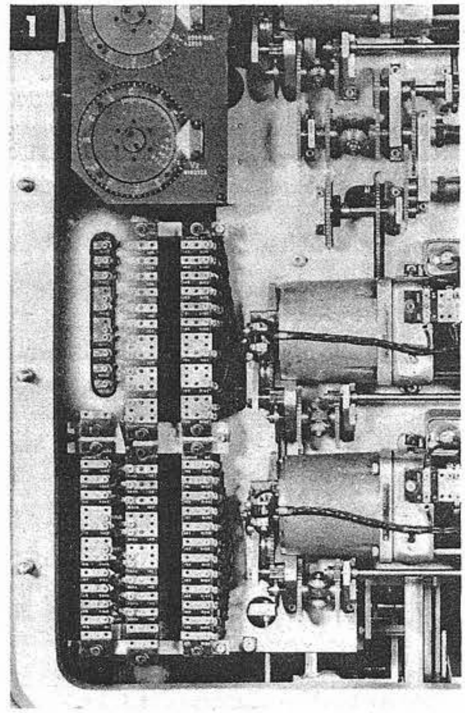
3 Remove the transmitters.

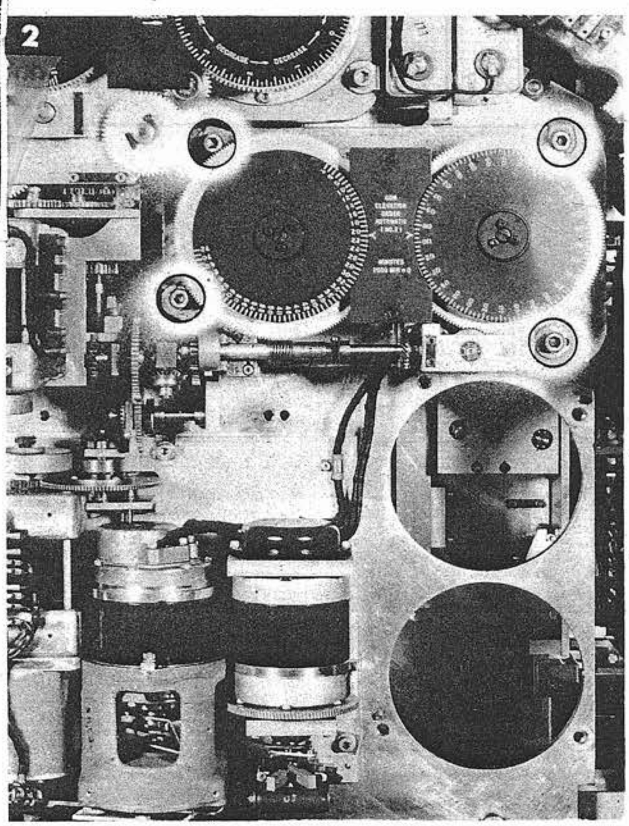
To reinstall the *E'g* indicating transmitters, reverse the removal procedure.
Readjust clamp A-5.
Run transmission tests.

E'g AUTOMATIC TRANSMITTERS

E'g Indicating Transmitters, page 757

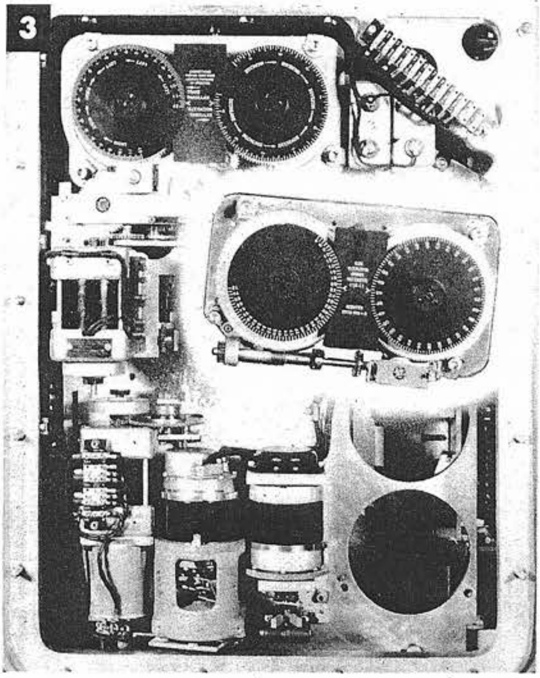




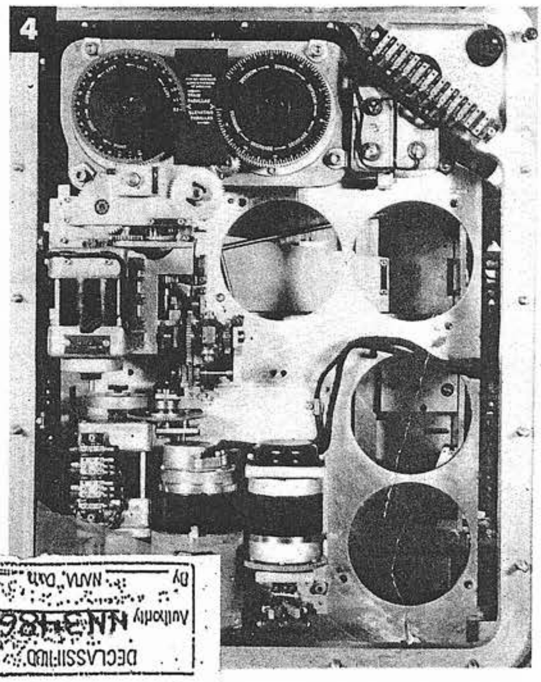


1 Remove the ten screws connecting the transmitter cable leads to the terminal block under the rear cover.

2 Remove the four screws securing the transmitters.



3 Work the dowels loose. Lift the transmitters to disengage the gear meshes.



4 Remove the transmitters.

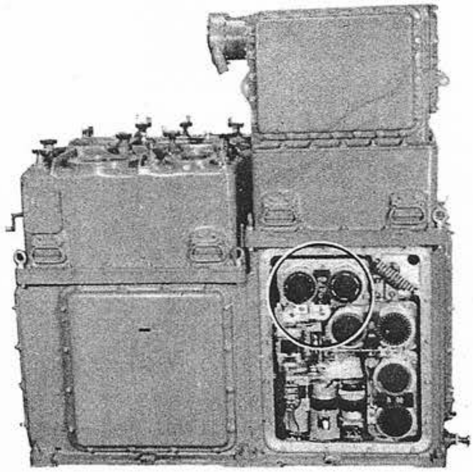
To reinstall the *E′g* automatic transmitters, reverse the removal procedure.

Reinstall the *E′g* indicating transmitters.

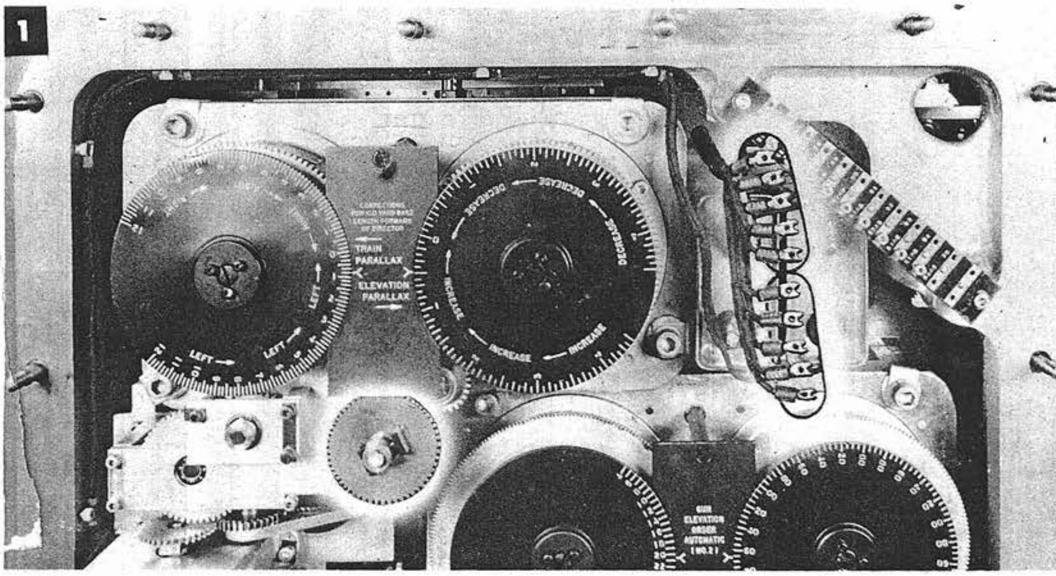
Readjust clamps A-5 and A-51.

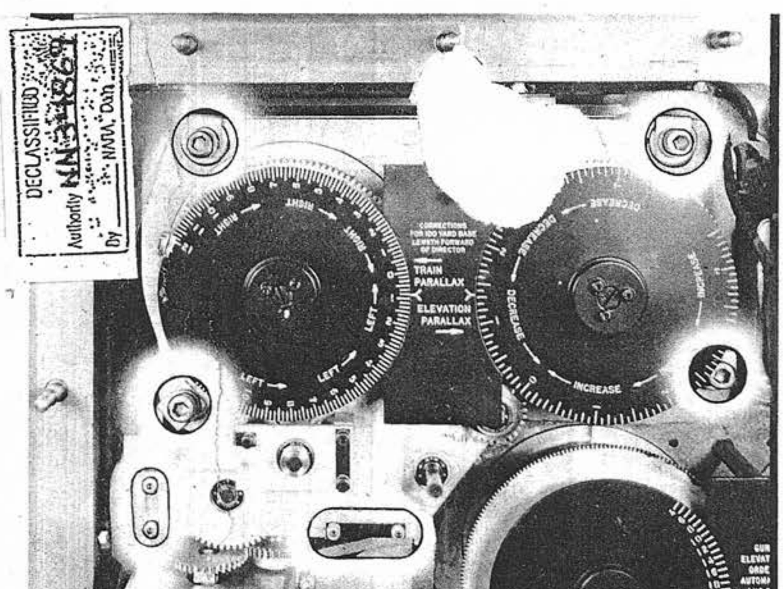
Run tests.

PARALLAX TRANSMITTERS



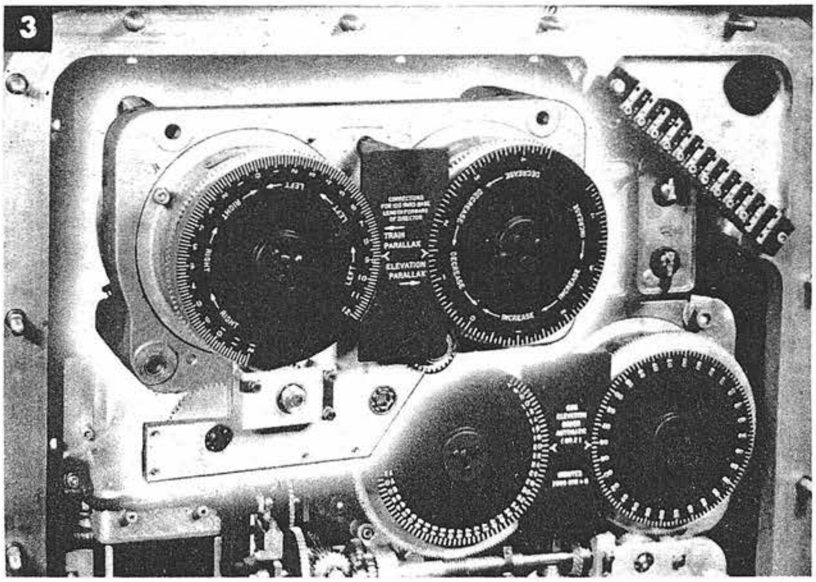
1 Remove the ten screws connecting the cable leads to the terminal block.
Unpin the collar over clamp A-228. Remove the collar, the gear and clamp, and the spacer.



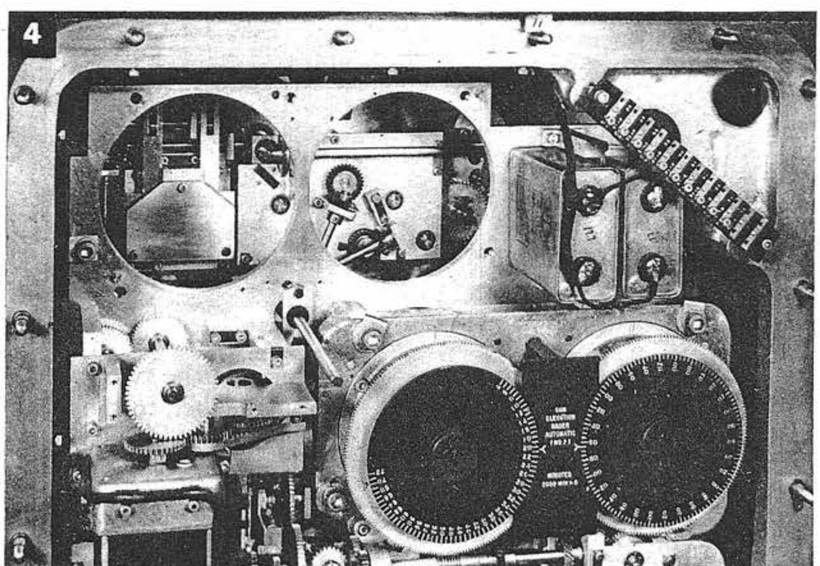


2 Remove the four small screws securing the plate below the transmitters.
Remove the four large screws securing the transmitters.

Gene Slover's US Navy Pages | Table of Contents



3 Pull the transmitters out to reach the two screws securing the cable clamps behind the upper edge of the transmitter casting. Remove the two screws and free the cable.



4 Slide the transmitters straight out to clear the shaft from which clamp A-228 was removed.

To reinstall the parallax transmitters, reverse the removal procedure.

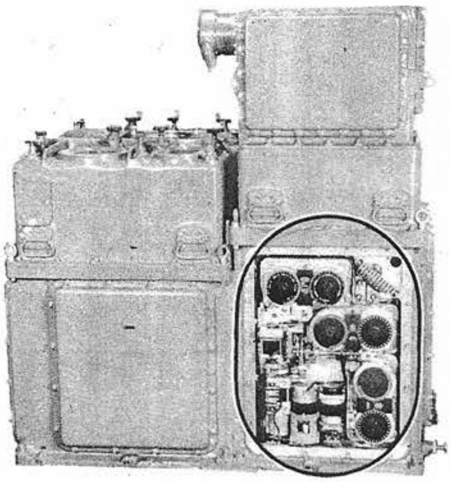
Check clamps A-517 and A-548 either before or after reinstallation.

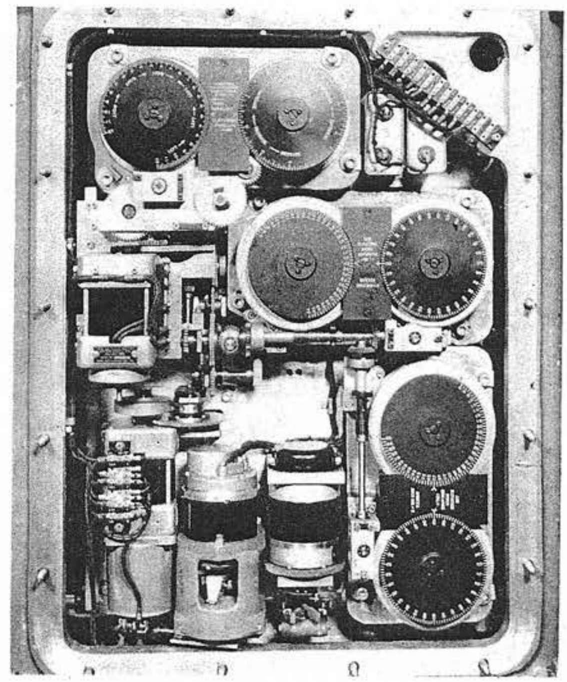
Readjust clamps A-52 and A-228.

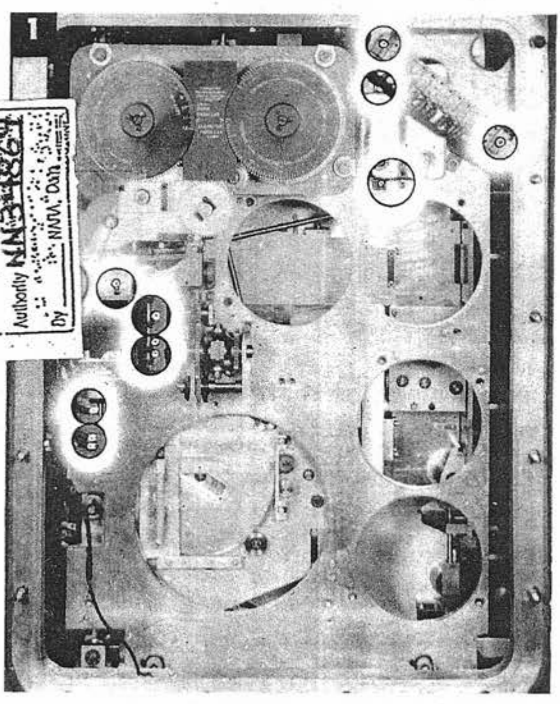
Run tests.

Eb, E'g MOUNTING PLATE

Eb Receiver, page 755
E'g Indicating Transmitters, page 757
E'g Automatic Transmitters, page 758





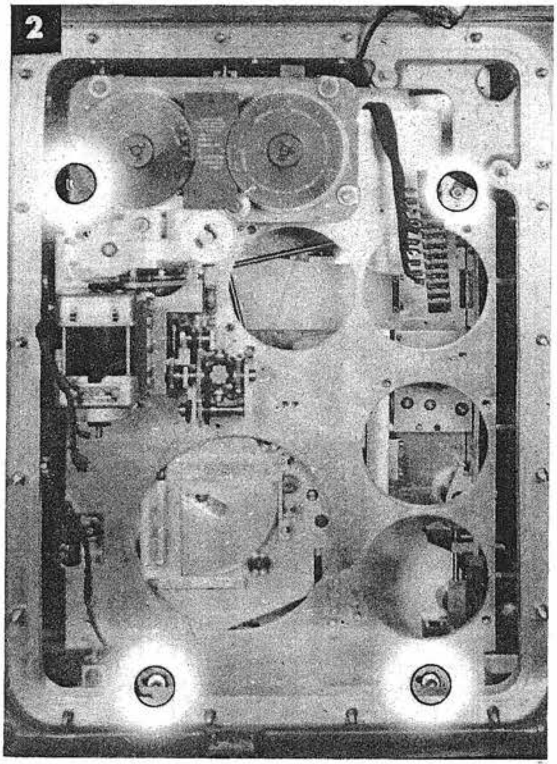


1 Remove the two screws securing the terminal block to the computer case.

Remove the four screws from the capacitor hangers.

Disconnect the cable leads from the servo motor.

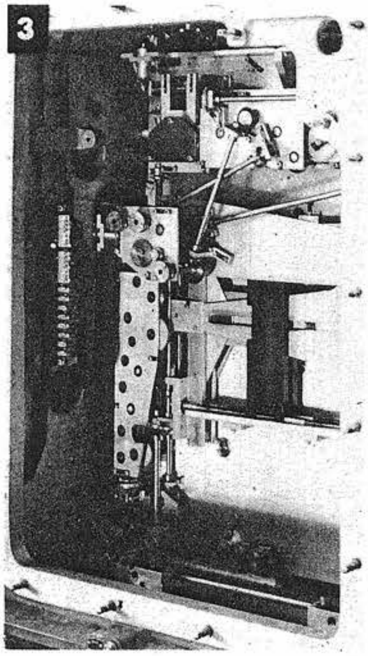
Loosen the three screws securing the cable clamps to the servo motor.
Free the cable.

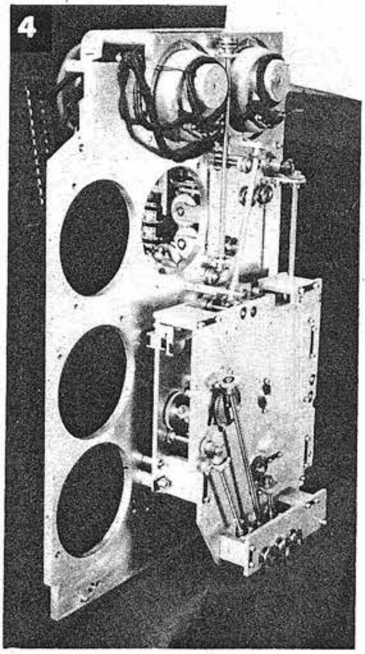


2 Push the capacitors and the terminal block aside.
Remove the four screws securing the plate.

3 Work the plate dowels loose from the mounting brackets. Remove the plate.

4 Rear view of removed plate.





To reinstall the *Eb, E′g* mounting plate, reverse the removal procedure.

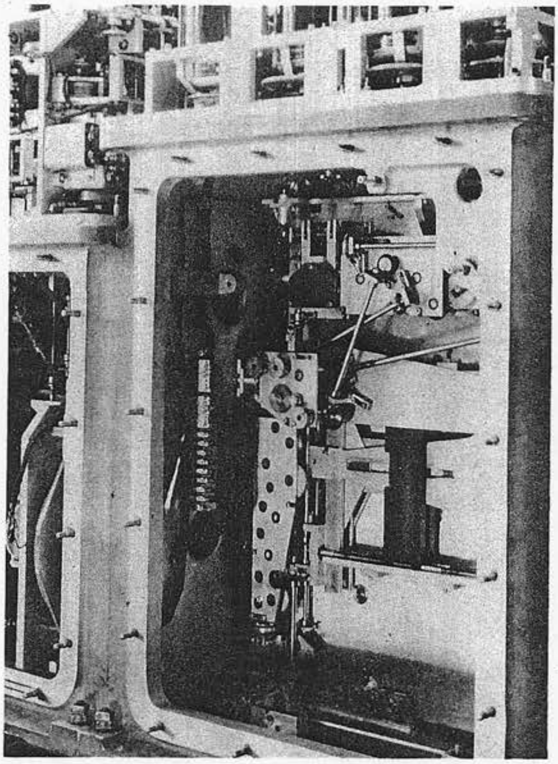
Readjust clamps A-243, A-49, A-52, A-226, A-227, A-228, A-156, A-3, A-51, A-50, A-5, and A-231.

Check clamps A-513, A-514, A-515, A-516, A-517, A-548, A-4, and A-6, either before or after reinstallation.

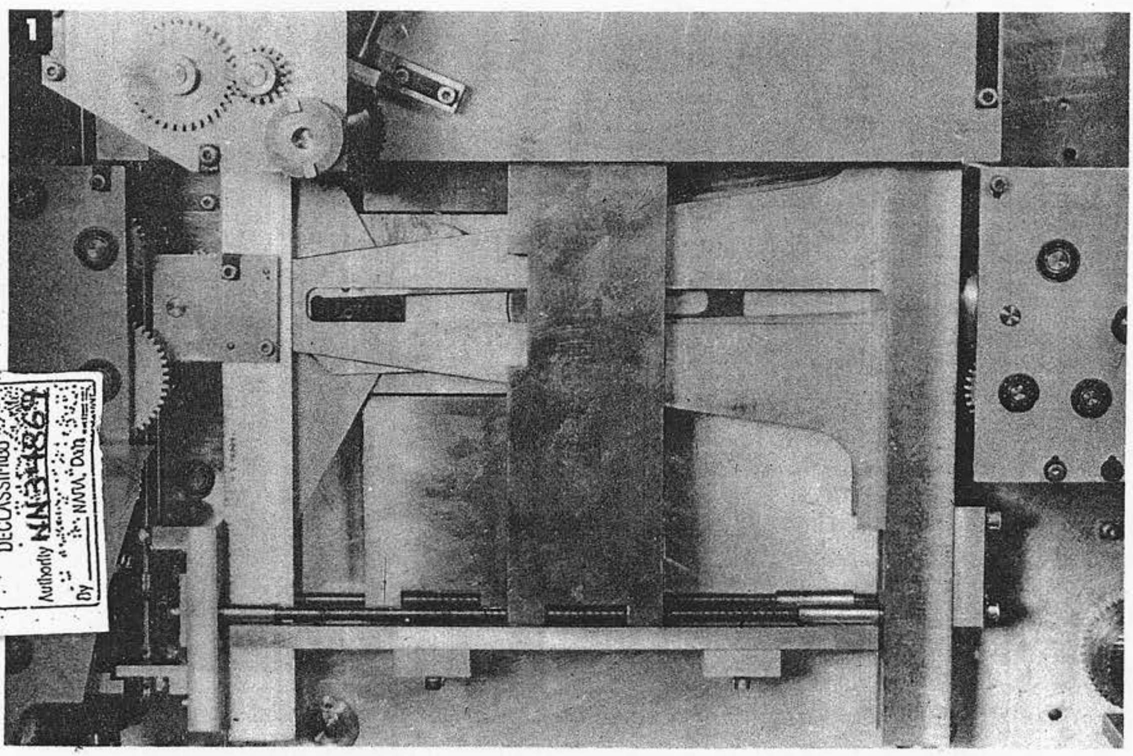
Run tests.

L • L sin 2B′r AND Zd (L – L cos 2B′r) MULTIPLIERS

Eb Receiver, page 755
E′g Indicating Transmitters, page 755
E′g Automatic Transmitters, page 758
Eb, E′g Mounting Plate, page 762



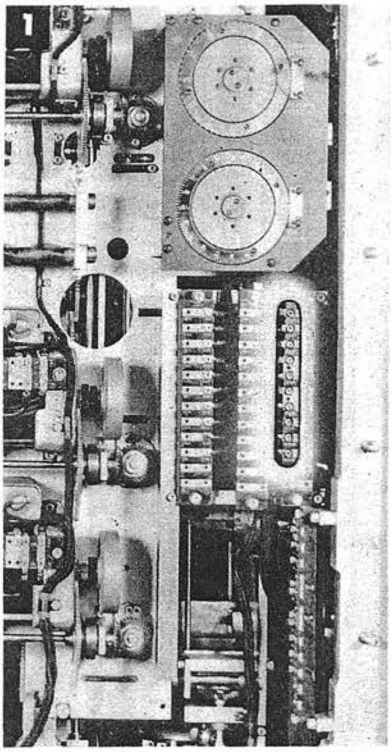
1 Work can be done on any part of the $L \cdot L$ sin $2B'r$ and Zd $(L - L$ cos $2B'r)$ multipliers and associated gearing without removing them from the instrument.

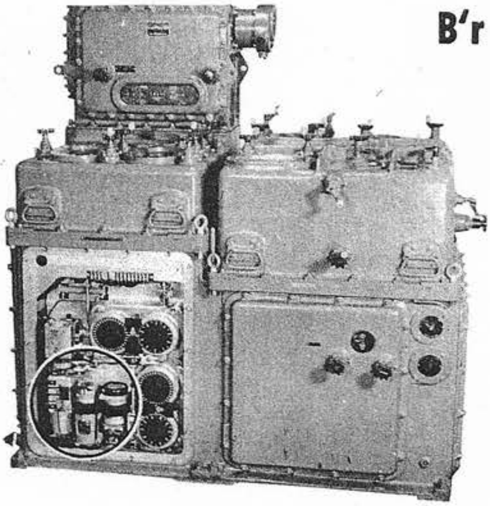


Reinstall the mechanisms removed.

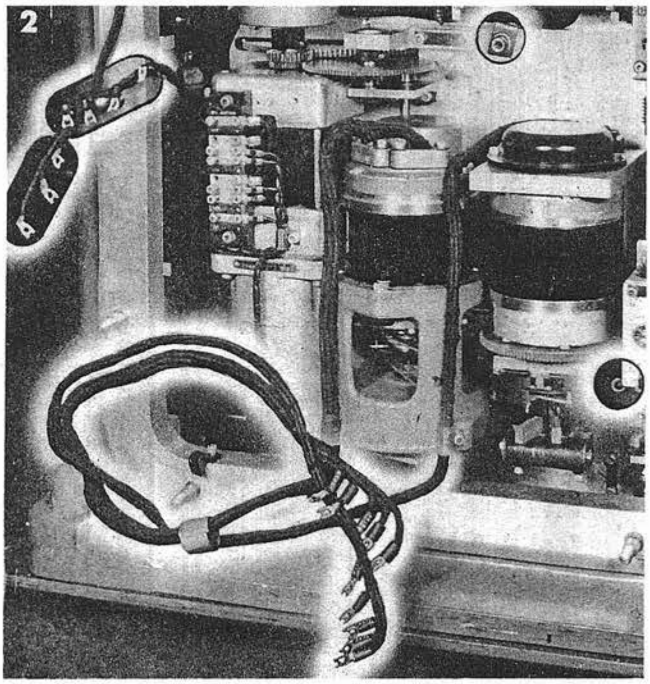
Readjust clamps A-505, A-112, A-99, A-28, A-58, A-111, A-64, A-65, A-57, A-199, A-62, A-517, A-548, A-242, A-243, A-49, A-52, A-226, A-228, A-227, A-156, A-3, A-513, A-514, A-515, A-516, A-4, A-6, A-5, A-51, A-50, and A-231.

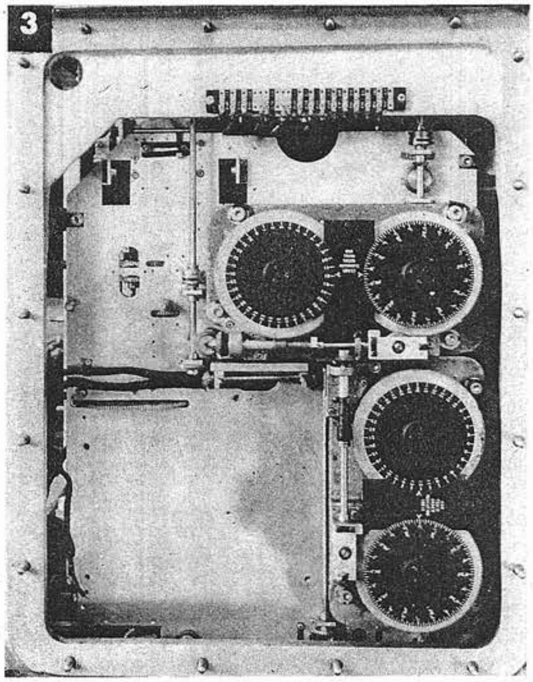
B'r RECEIVER





1 Remove the ten screws connecting the *B'r* receiver cable leads to the terminal block under the rear cover.





2 Pull the cables through to the receiver side of the computer.
Remove the screws connecting the external cable leads to the servo terminal block.
Remove the two screws securing the cable clamps near the receiver.
Remove the four screws securing the receiver.

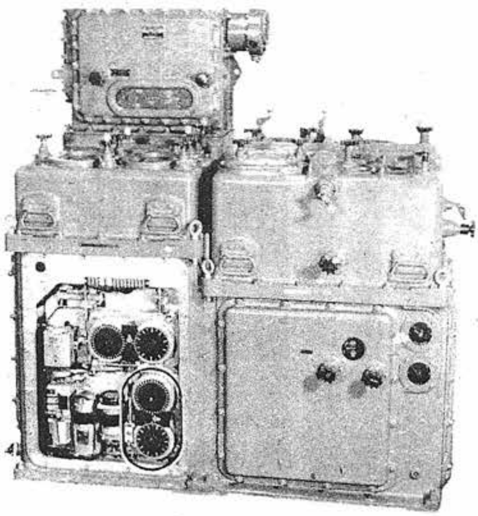
3 Remove the receiver.

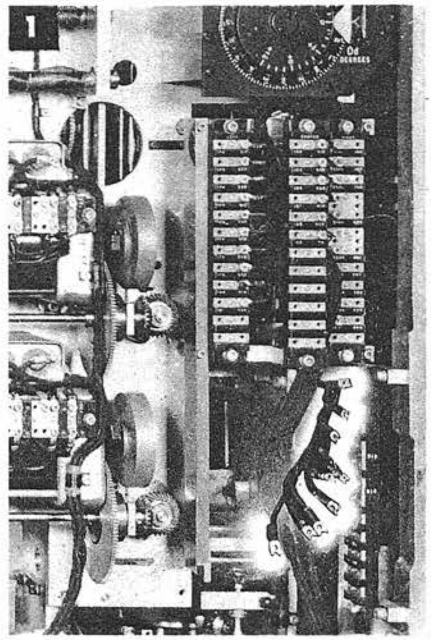
To reinstall the receiver, reverse the removal procedure.

Readjust clamp A-98.

Run tests.

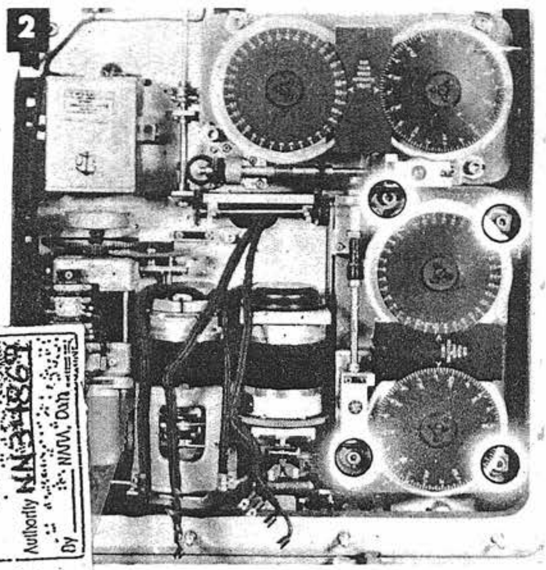
B′gr INDICATING TRANSMITTERS

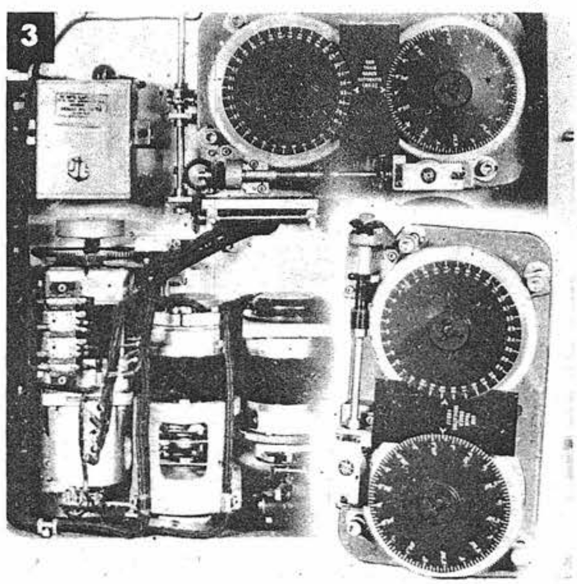




1 Remove the ten screws connecting the transmitter cable leads to the terminal block under the rear cover.

2 Pull the cable through to the transmitter side of the instrument.
Remove the two screws securing the cable clamps above the *B′r* receiver.
Free the cable.
Remove the four screws securing the transmitters.





3 Remove the mechanism, easing the cable through behind it.

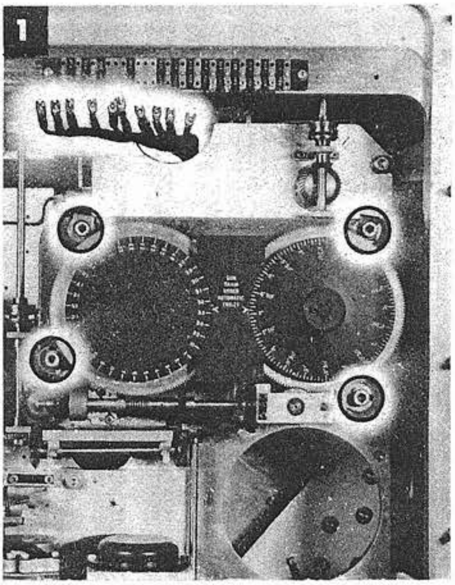
To reinstall the *B′gr* indicating transmitters, reverse the removal procedure.

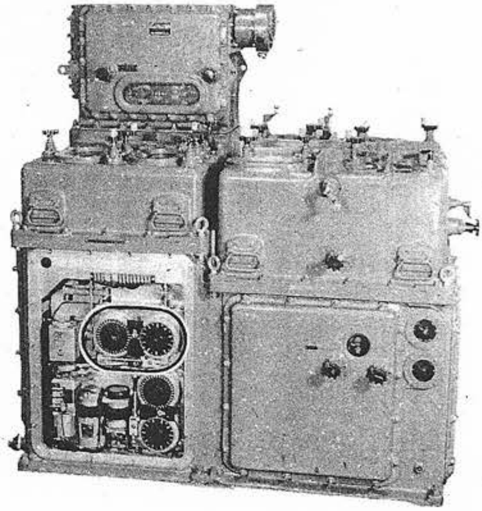
Readjust clamp A-8.

Run tests.

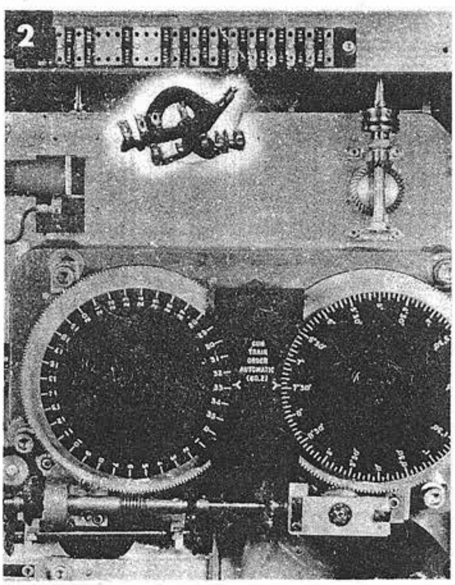
B'gr AUTOMATIC TRANSMITTERS

B'gr Indicating Transmitters, page 766



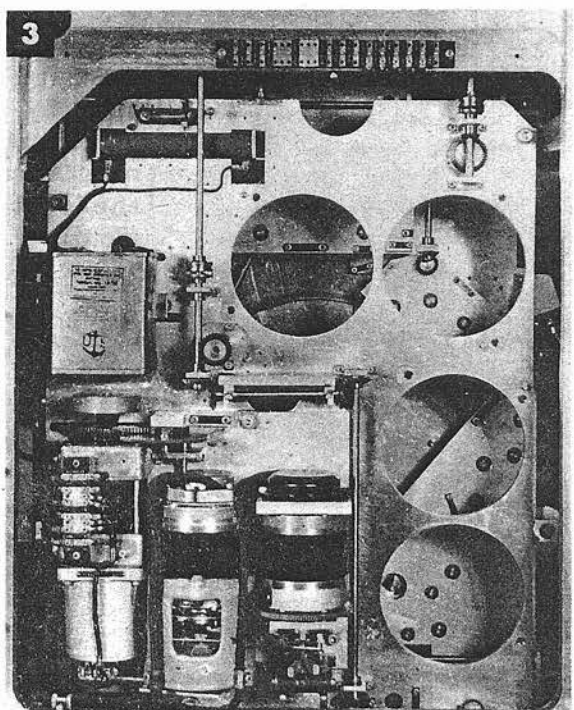


1 Remove the ten screws connecting the transmitter cable leads to the terminal block directly above the transmitters. Remove the four screws securing the transmitters.



2 Ease the cable over the top of the mounting plate.

3 Remove the transmitters.



To reinstall the *B'gr* automatic transmitters, reverse the removal procedure.

Loosen assembly clamp A-68.

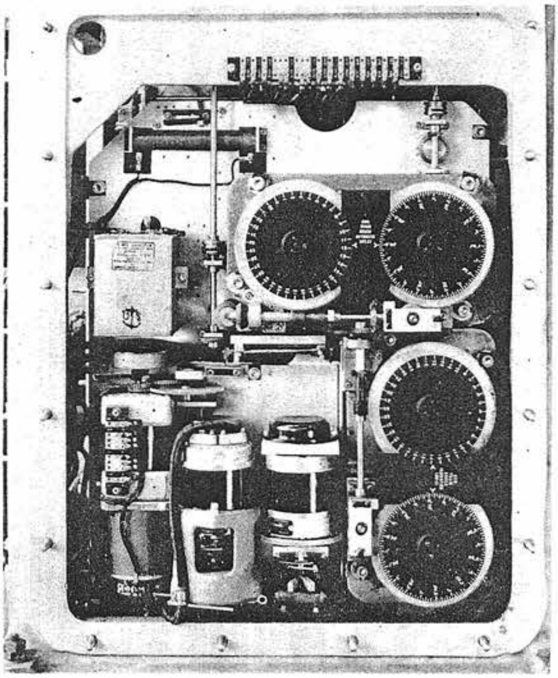
Readjust clamp A-8.

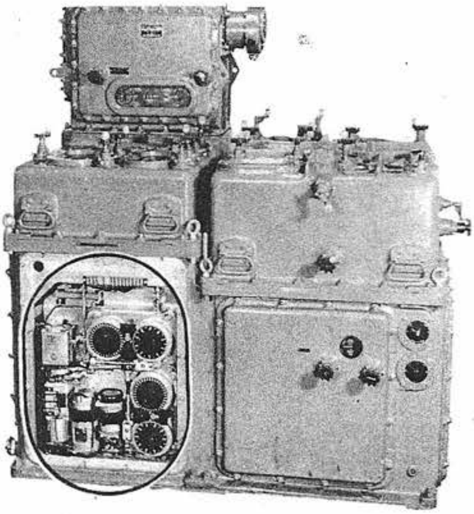
Set *Dd*, *Br*, *L*, and *Zd* on zero. Turn the transmitters to electrical zero and tighten A-68.

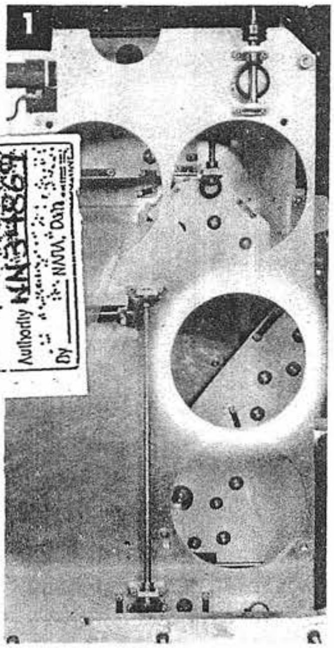
Run tests.

B′r, B′gr MOUNTING PLATE

B′r Receiver, page 765
B′gr Indicating Transmitters, page 766
B′gr Automatic Transmitters, page 767



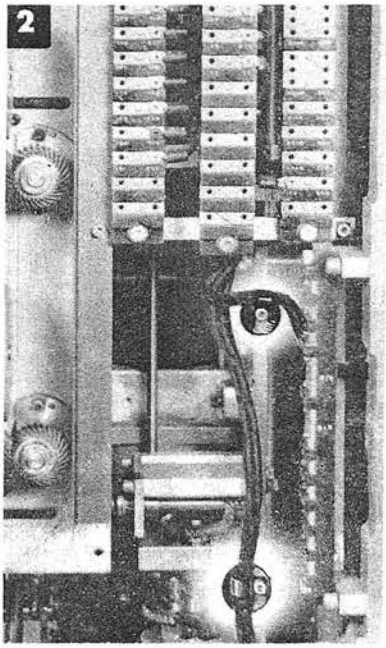




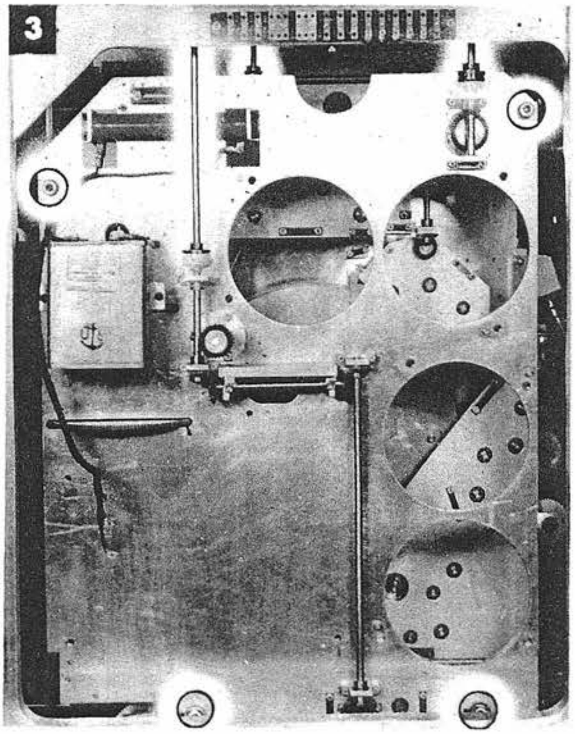
1

1 Through the opening made by removal of the *B′gr* transmitters, disconnect the cable leads from the local control servo motor.

2 Loosen the two screws securing the cable clamps to the rear edge of the mounting plate. Free the cable.



2

3


3 Remove the locking springs from the three vertical coupling shafts at the top of the plate. Remove the shafts.
Remove the four screws securing the plate. Work the dowels free.

To reinstall the mounting plate, reverse the removal procedure

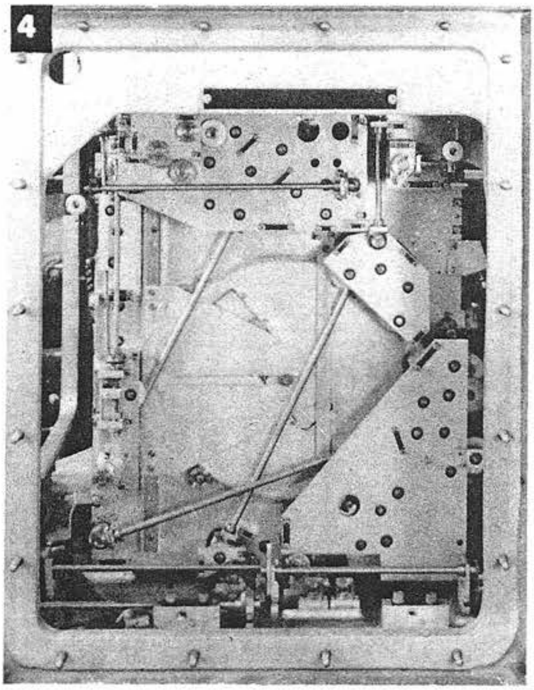
Reinstall the other mechanisms removed.

Check clamps A-509, A-510, A-511, A-512, A-7, and A-9 either before or after reinstallation.

If the *Dj* dial cannot be set to the limit stop by proper mating of the coupling and gears, remove the star shell computer and indicator-unit cover and readjust clamps A-500, A-86, A-243, A-99, A-70, A-8, A-156, and A-98.

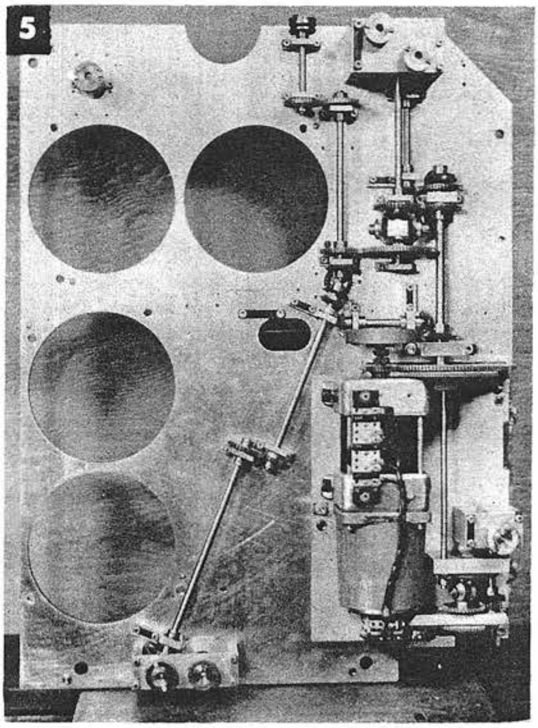
If the star shell computer is removed, readjust A-17, A-230, and A-231.

Run tests.

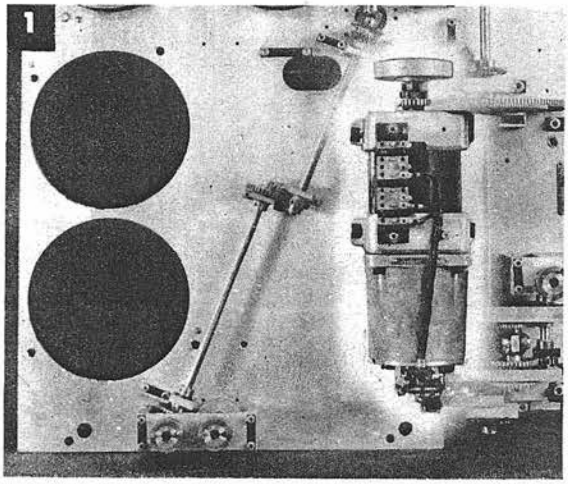
4


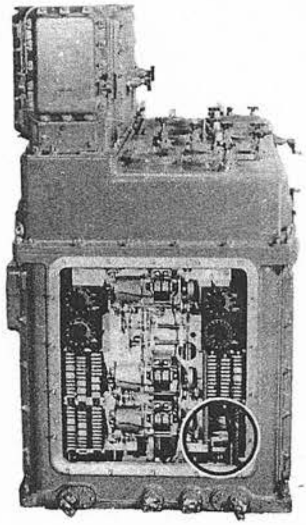
4 Remove the plate.

5 Rear view of the plate.

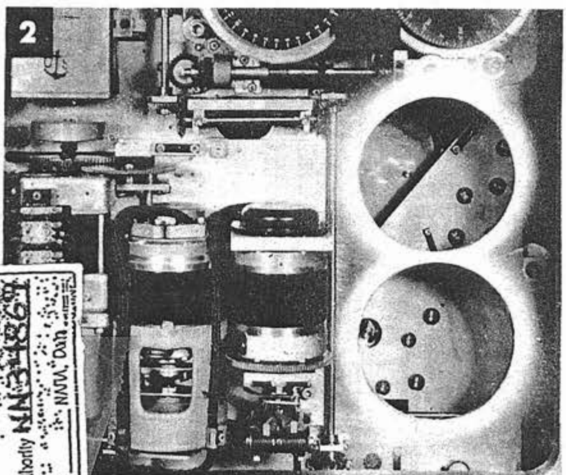
5


B'r LOCAL CONTROL FOLLOW-UP

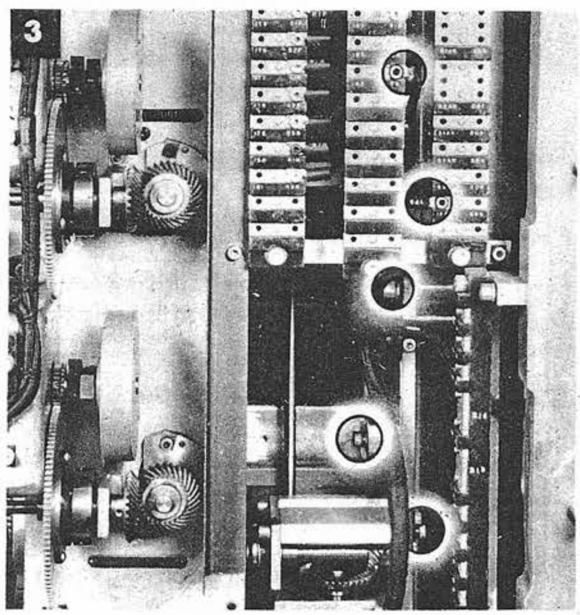




1 The *B'r* local control follow-up is on the back of the *B'r, B'gr* mounting plate.



2 This follow-up can also be reached through the access cleared by removal of the *B'gr* indicating transmitters.



3 Working from the rear of the computer through the *B'gr* transmitter holes, remove the screws connecting the external cable leads to the servo motor terminal block. Remove the four screws securing the follow-up and remove it.

To reinstall the follow-up, reverse the removal procedure.

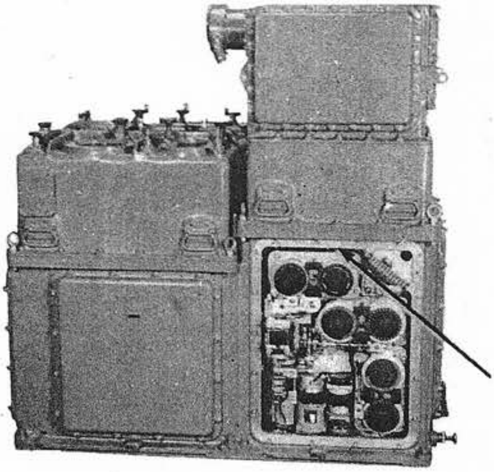
Reinstall the *B'gr* indicating transmitters.

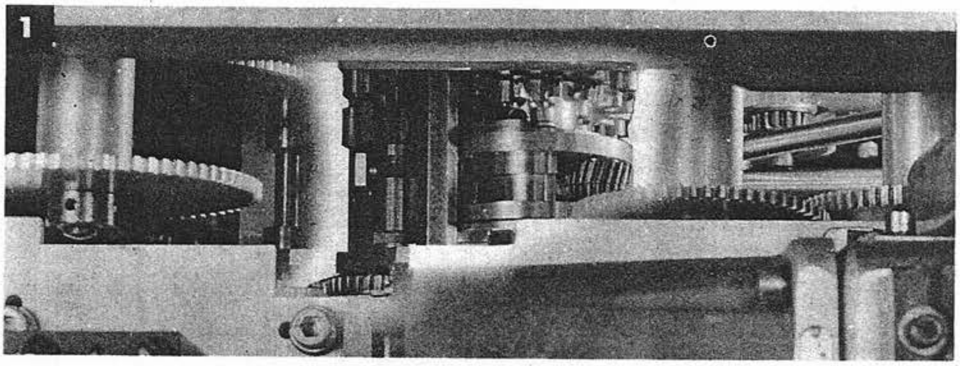
Readjust clamps A-70 and A-8.

Run tests.

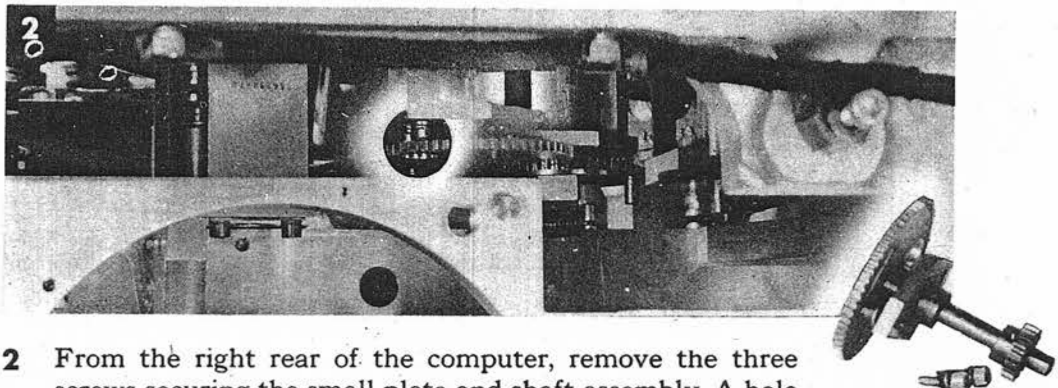
Vs INTERMITTENT DRIVE

Parallax Transmitters, page 760

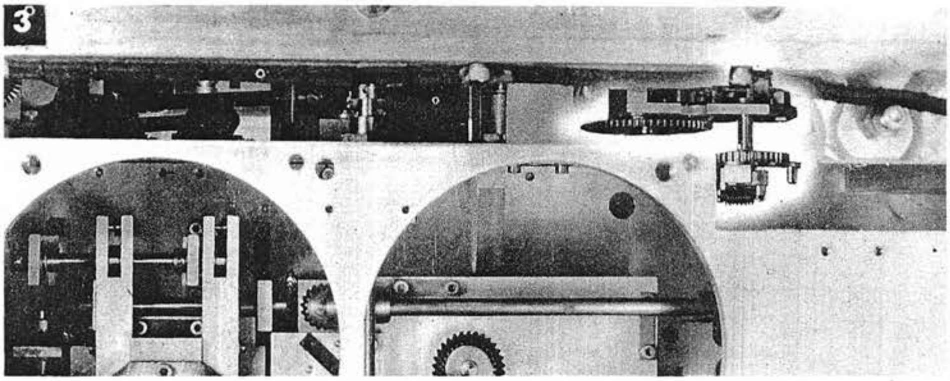




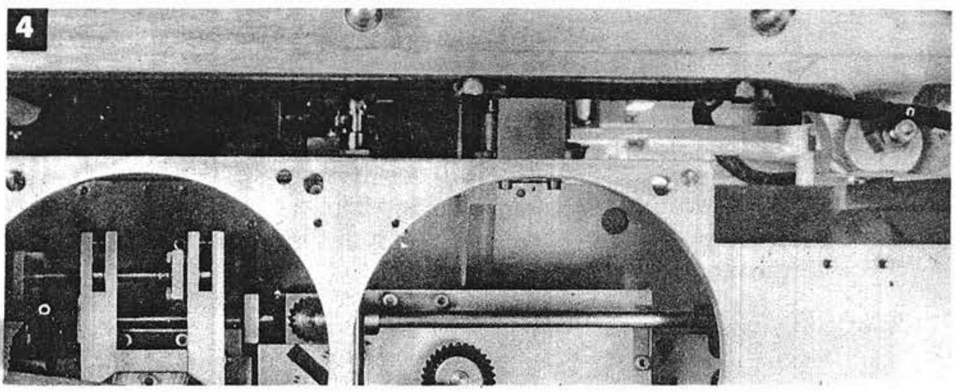
1 The *Vs* intermittent drive is removed from the right rear of the computer, but it can be seen from the rear if the *Ds* intermittent drive has been removed.



2 From the right rear of the computer, remove the three screws securing the small plate and shaft assembly. A hole in the gear allows access to the screws.
Remove the plate and shaft assembly.
Remove the hexagonal post that supports a corner of the plate.



3 Remove the three screws securing the intermittent drive to the upper plate. Two of the screws can be reached from the right rear; the third, from the back of the computer. Loosen clamp A-114 if necessary.



4 Remove the intermittent drive.

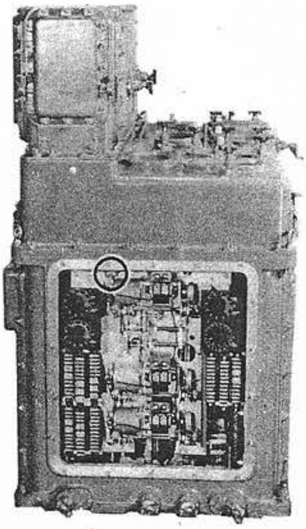
To reinstall the intermittent drive, reverse the removal procedure.

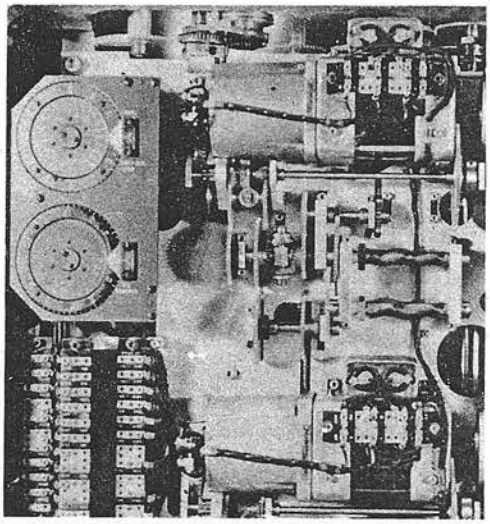
Reinstall the parallax transmitters.

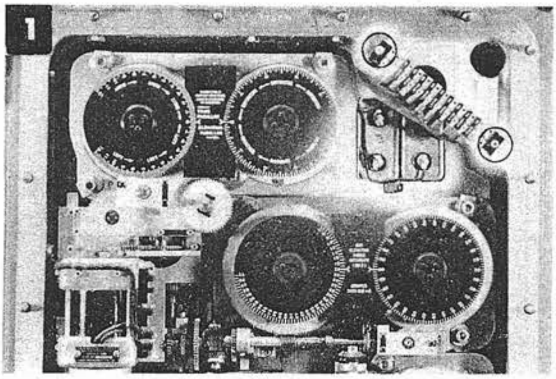
Tighten clamp A-114.

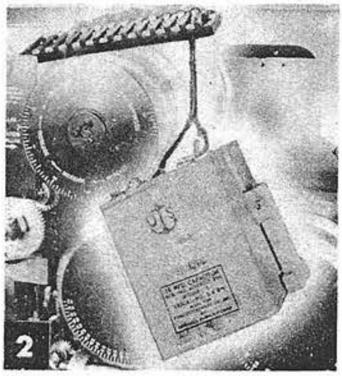
Readjust clamps A-97, A-69, A-517, A-548, A-52, and A-228.

Ds INTERMITTENT DRIVE



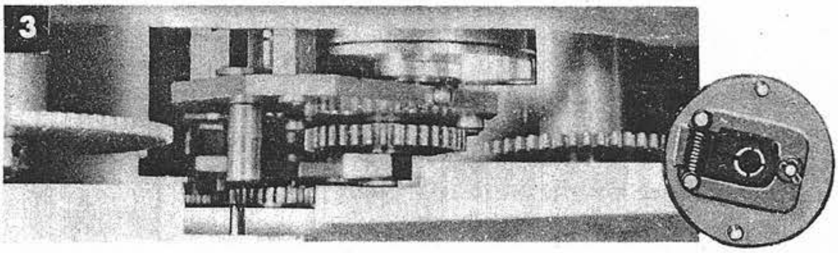




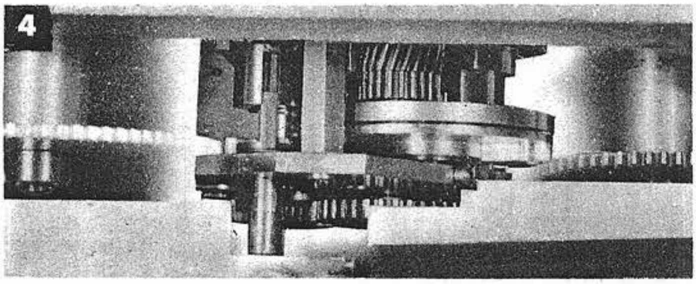


1 Remove the two screws securing the terminal block.
Remove the four screws securing the capacitors above the $E'g$ automatic transmitters.

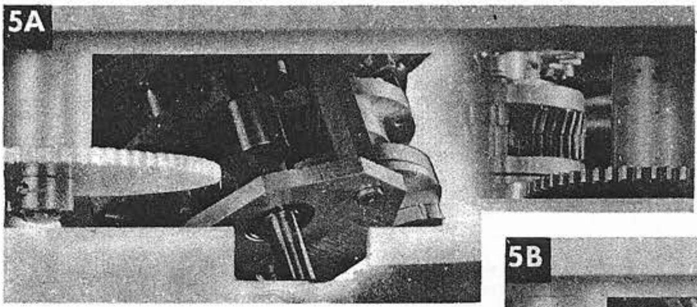
2 Move the terminal block and the capacitors out of the way.

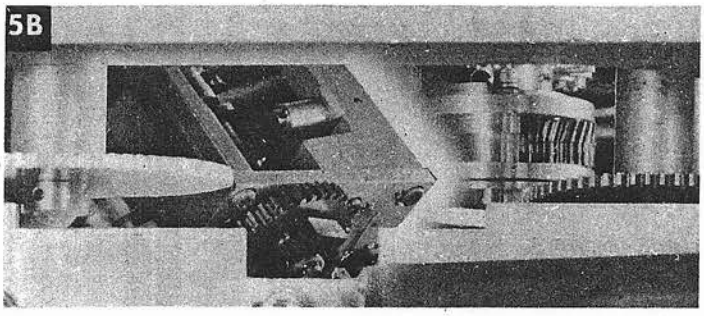


3 Loosen the shock absorber assembly clamp A-114.
Remove the assembly from the intermittent drive.



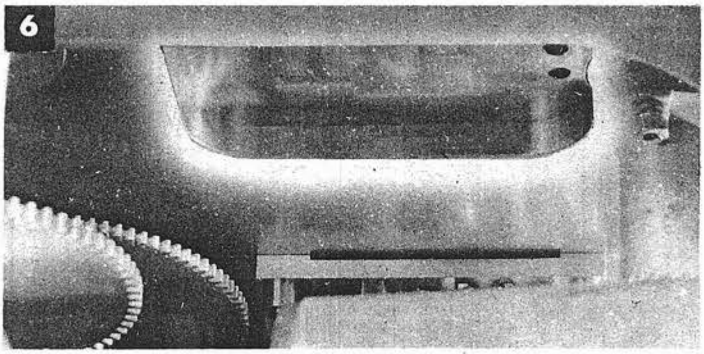
4 Through the access allowed by removal of the capacitors, move the intermittent drive toward the front of the computer.





5 Turn the intermittent drive to clear the plate below it.

emove the intermittent ive through the access the right rear.

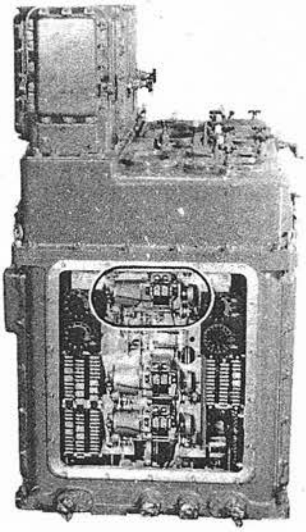


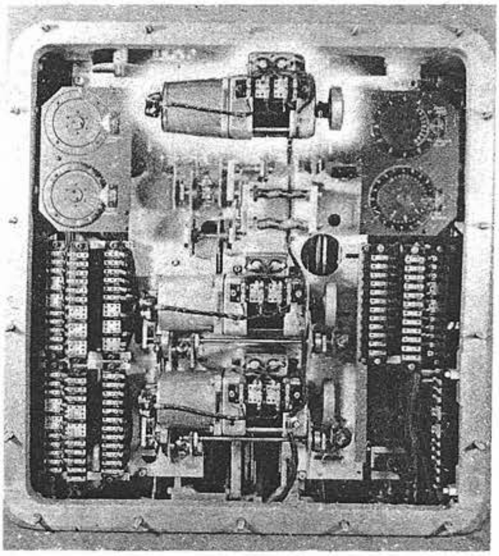
To reinstall the *Ds* intermittent drive, reverse the removal procedure.

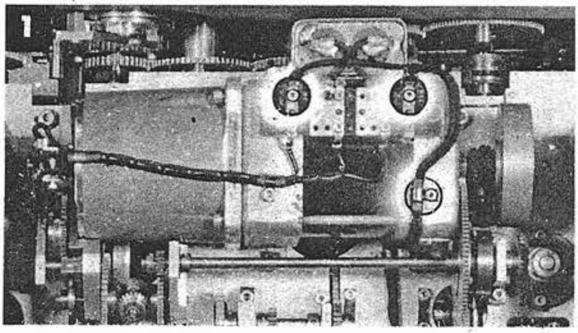
Tighten clamp A-114.

Readjust clamps A-96 and A-66.

Dd FOLLOW-UP

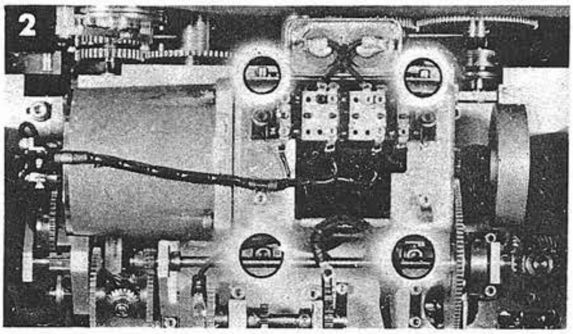




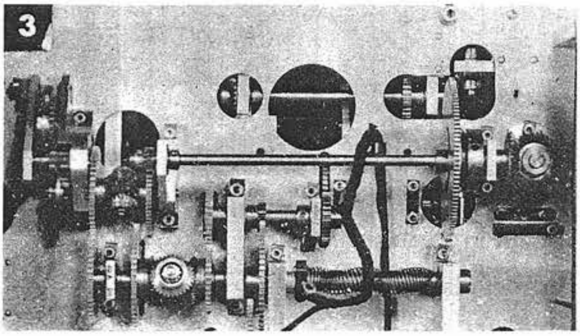


1 Remove the two screws connecting cable leads 1B and 1BB to the servo motor terminal block.

Remove the screw securing the cable clamp to the servo motor case. Free the cable.



2 Remove the four screws securing the follow-up to the mounting plate. Support the follow-up while removing the last screw.



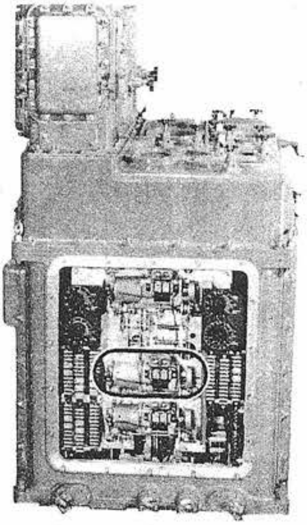
3 Remove the follow-up.

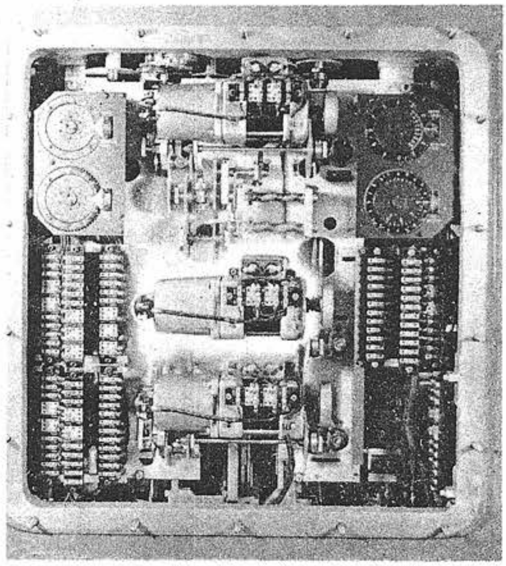
To reinstall the *Dd* follow-up, reverse the removal procedure.

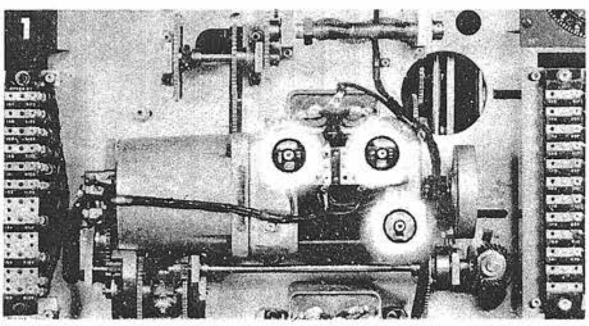
Readjust clamp A-33.

Run tests.

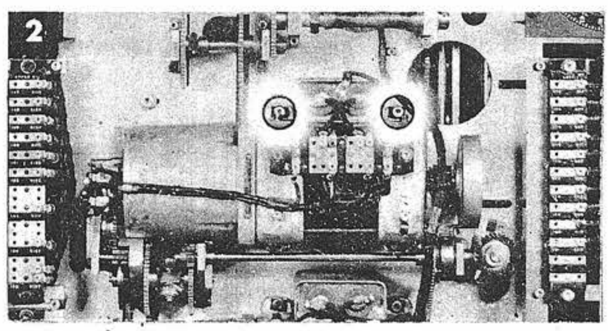
jB'r FOLLOW-UP





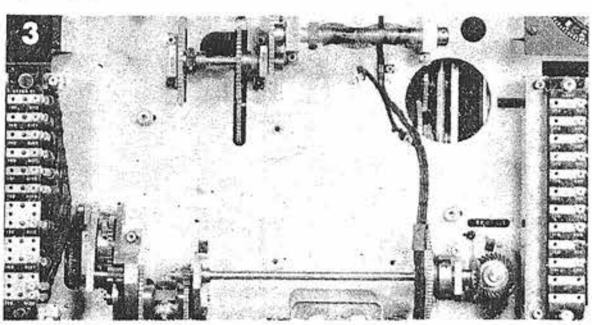


1 Remove the two screws connecting cable leads 1C and 1CC to the servo terminal block.
Remove the screw securing the cable clamp to the servo motor. Free the cable.



Remove the four screws securing the follow-up. Support the follow-up while removing the last screw.

Remove the follow-up.

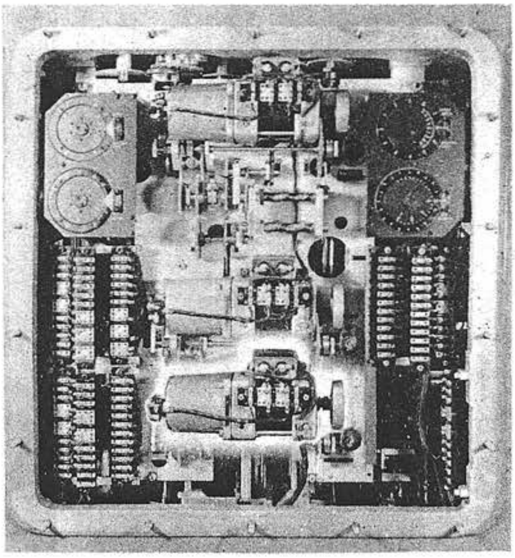


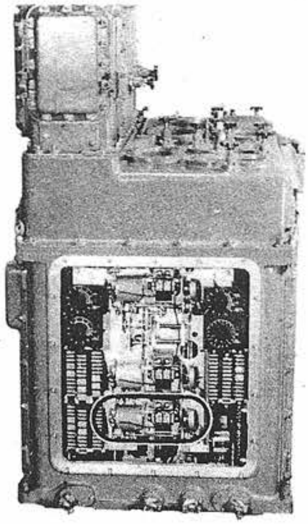
To reinstall the *jB'r* follow-up, reverse the removal procedure.

Readjust clamp A-62.

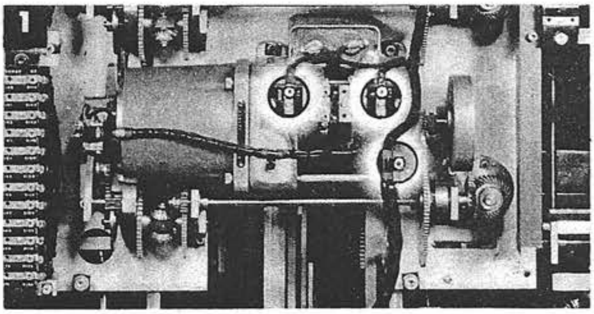
Run tests.

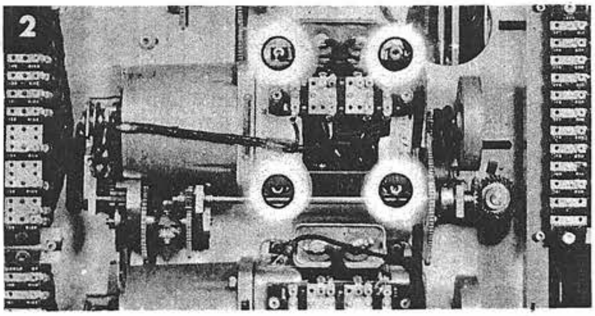
Vz FOLLOW-UP





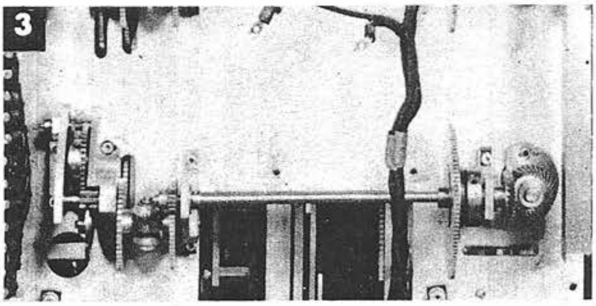
1 Remove the two screws connecting cable leads 1D and 1DD to the servo motor terminal block.
Remove the screw securing the cable clamp to the servo motor. Free the cable.





2 Remove the four screws securing the follow-up. Support the follow-up while removing the last screw.

3 Remove the follow-up.



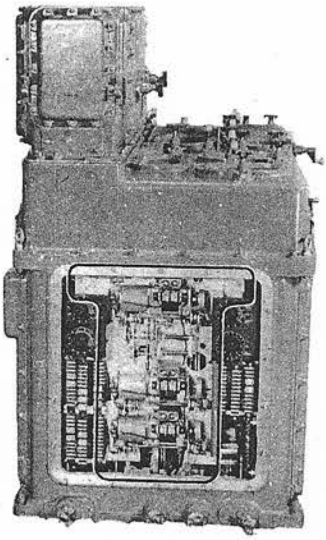
To reinstall the *Vz* follow-up, reverse the removal procedure.

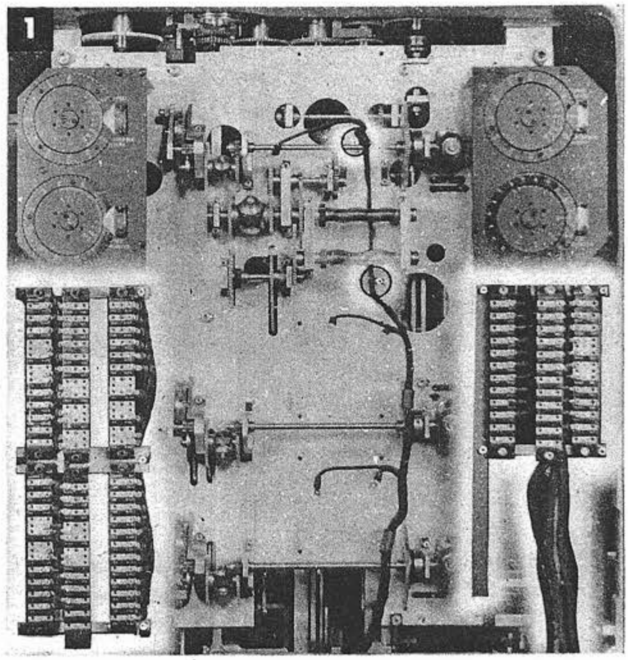
Readjust clamp A-63.

Run tests.

Dd, jB'r, Vz FOLLOW-UP MOUNTING PLATE

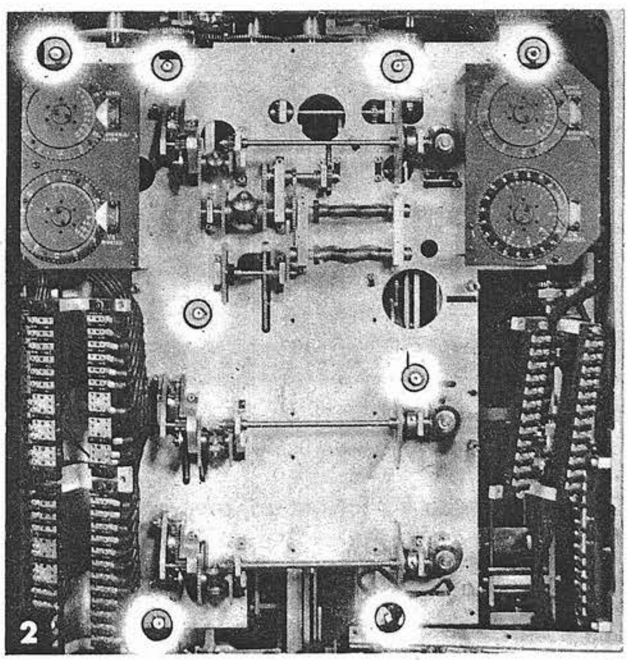
Dd, jB'r, and *Vz* Follow-ups, pages 775, 776, 777.

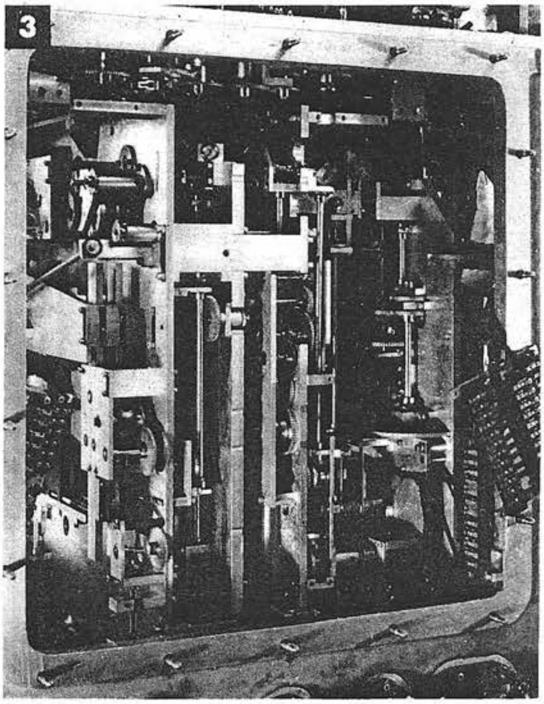




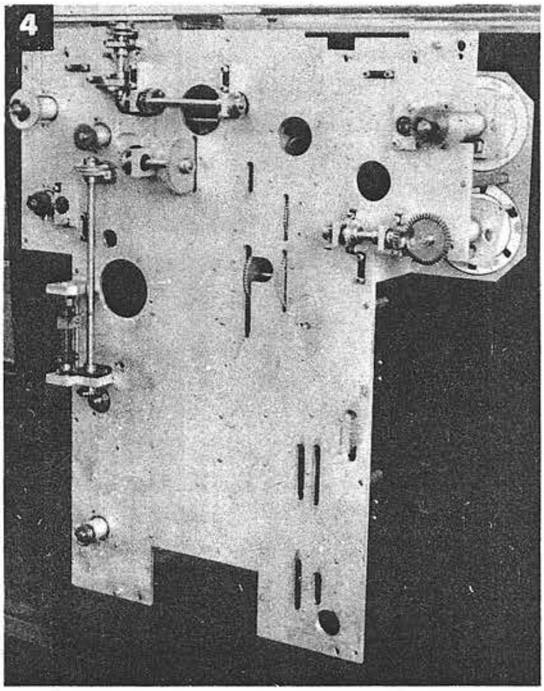
1 Remove the screws securing the frames of the terminal blocks.
Remove the screws securing the cable clamps to the plate. Free the cable.

emove the eight screws securing the ounting plate.





3 Push the terminal blocks aside. Work the dowels free. Remove the plate.



4 Rear view of the plate.

To reinstall the mounting plate, reverse the removal procedure.

Reinstall the three follow-ups.

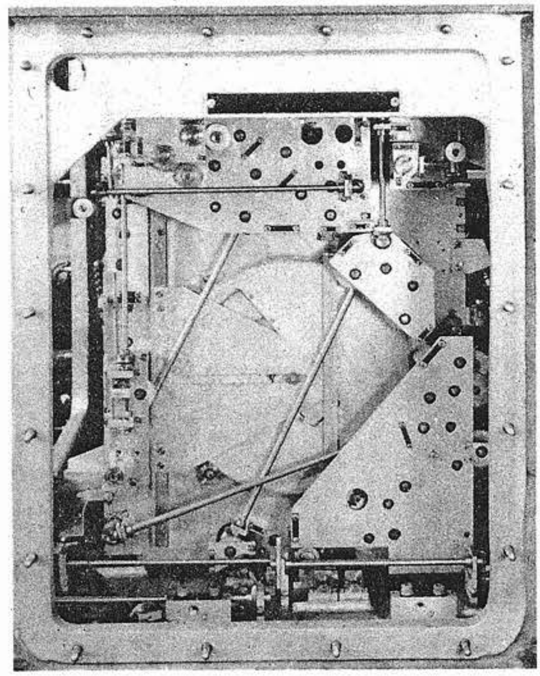
Readjust clamps A-507, A-30, A-505, A-506, A-29, A-508, A-31, A-99, A-28, A-58, A-35, A-112, A-208, A-113, A-63, A-36, A-215, A-33, A-216, A-34, A-61, A-32, A-111, A-64, A-65, A-57, A-199, A-62, and A-51.

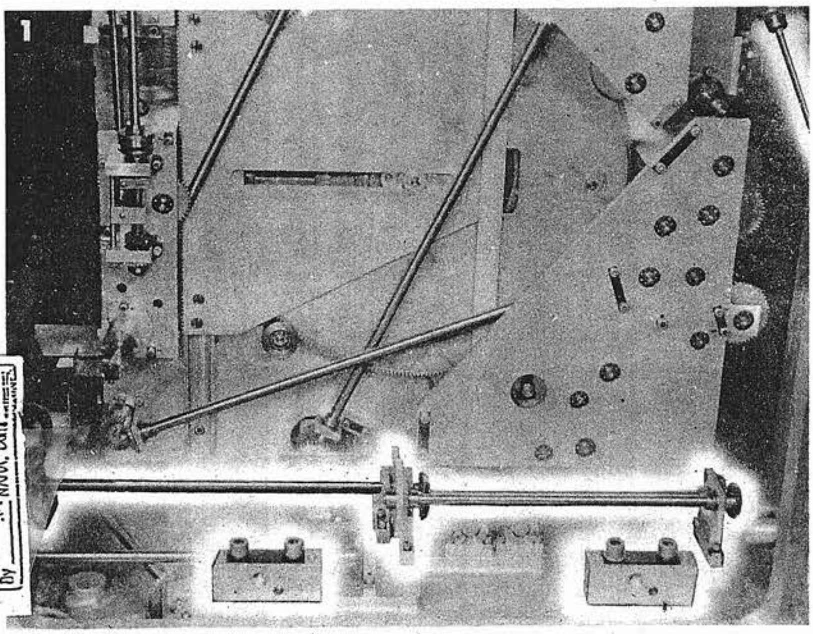
Check A-243, A-98, A-601, A-602, and A-603.

Run tests.

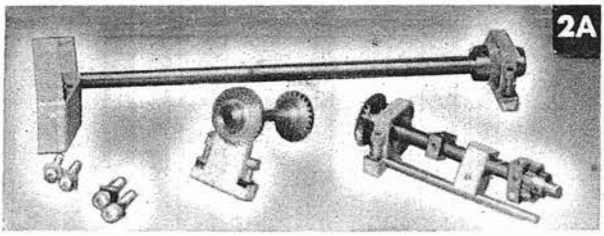
jDd AND Dz COMPUTERS

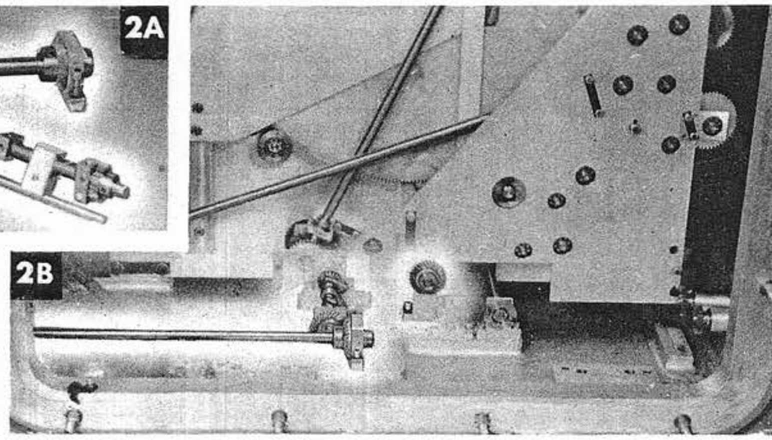
B'r Receiver, page 765
B'gr Indicating Transmitters, page 766
B'gr Automatic Transmitters, page 777
B'r, B'gr Mounting Plate, page 768
Dd, jB'r, Vz Follow-up Mounting Plate, page 778



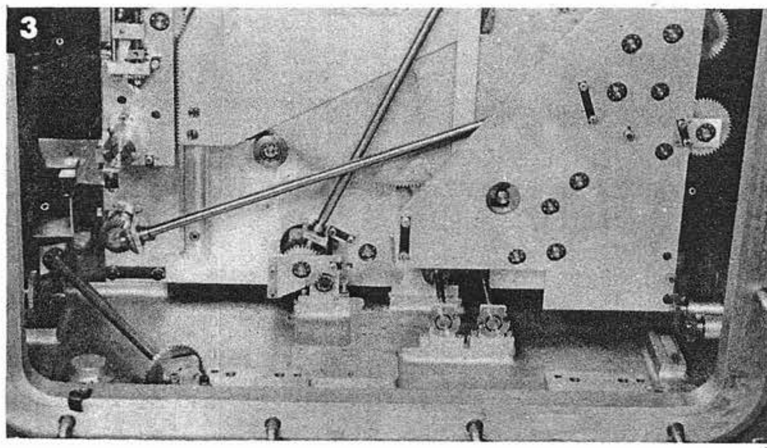


1 Remove the locking springs from the coupling shaft in the *Wrd + KRdBs* gearing line between the computer and corrector units. Remove the shaft.
Remove the four screws securing the mounting blocks to the floor of the computer. Remove the blocks.
Remove the eight screws from the three shaft assemblies at the base of the computer. Remove the assemblies.

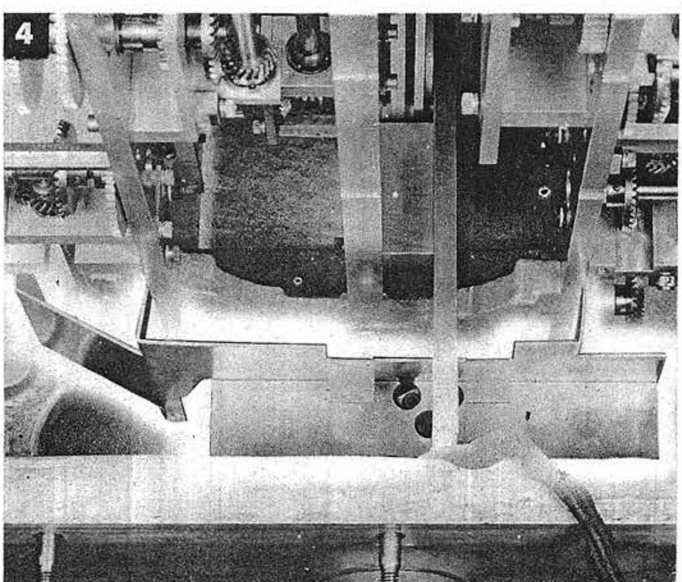




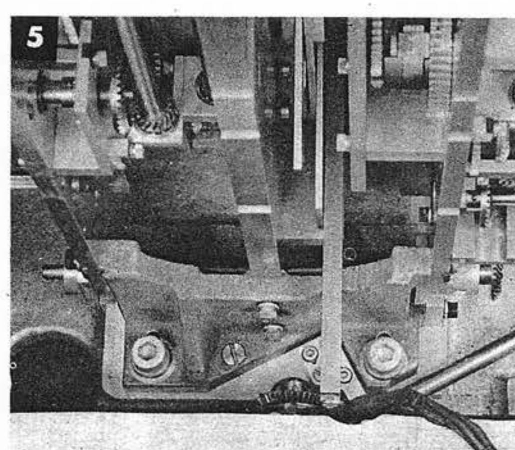
2 Remove the two screws securing the hanger of limit stop L-17. Remove the limit stop.
Remove the four screws securing the shaft assembly which connects with the *Zd* input. Remove the assembly.
Remove the two screws securing the outside hanger for the short shaft assembly which connects with the two couplings on the computer floor. Remove the assembly.



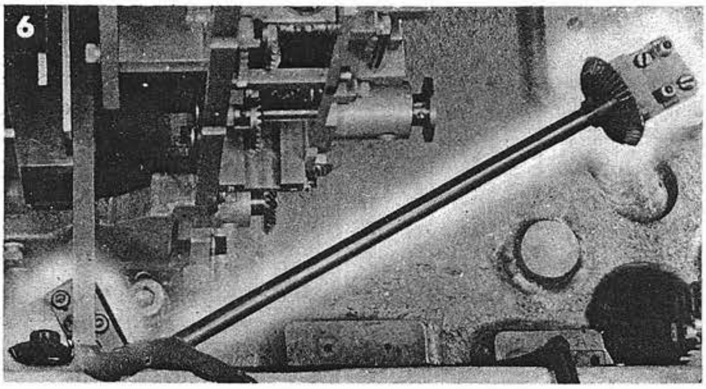
3 Remove the four screws securing the two brackets to the computer case. Remove the brackets.
Remove the two screws securing the bracket to the *Dz* mounting plate. Remove the bracket.



4 Remove the five screws securing the metal guard at the rear base of the computer.



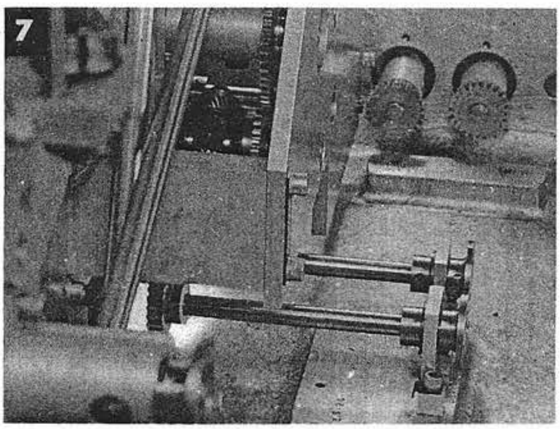
5 Remove the guard.

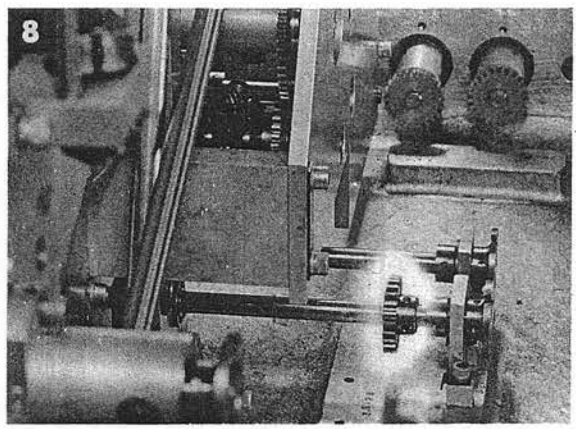


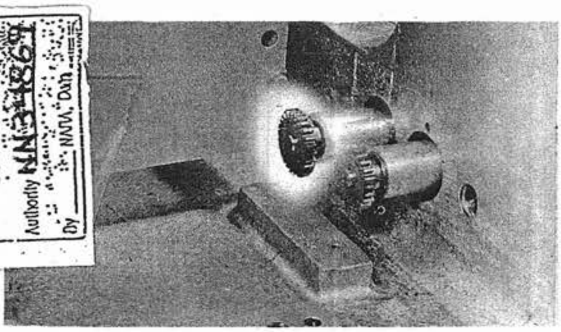
6 Remove the four screws securing the $B'r$ shaft assembly which meshes with the $B'r$ output shaft. Back out the four screw dowels. Remove the shaft assembly.

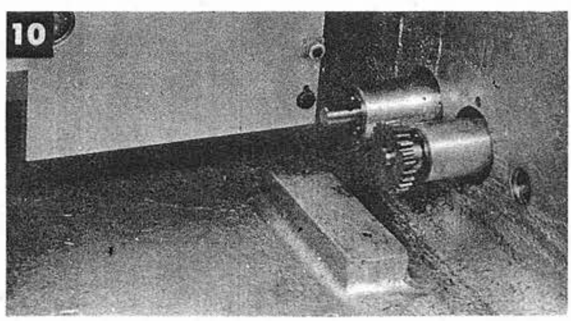
7 Unpin the spur gear near the *Dz* plate at the computer floor.

8 Slide the gear out on the shaft.







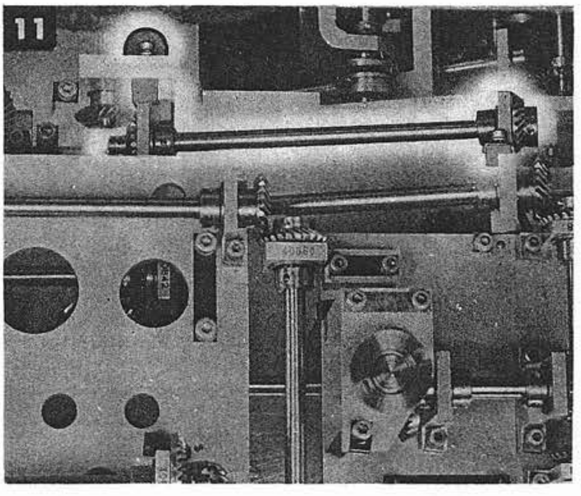


9 Unpin the inner spur gear extending from the adapter near the center division of the two units.

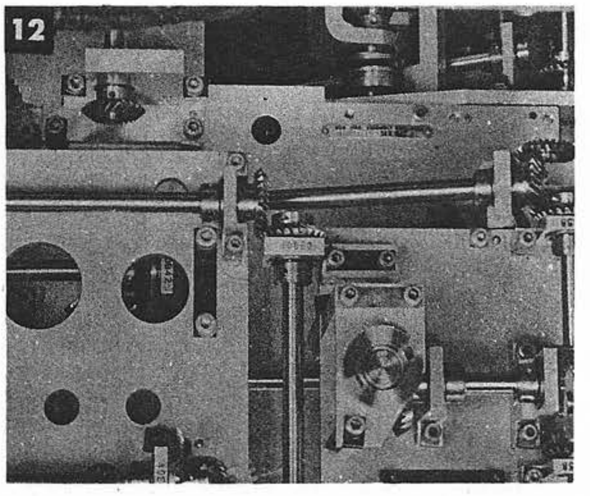
10 Remove the gear.

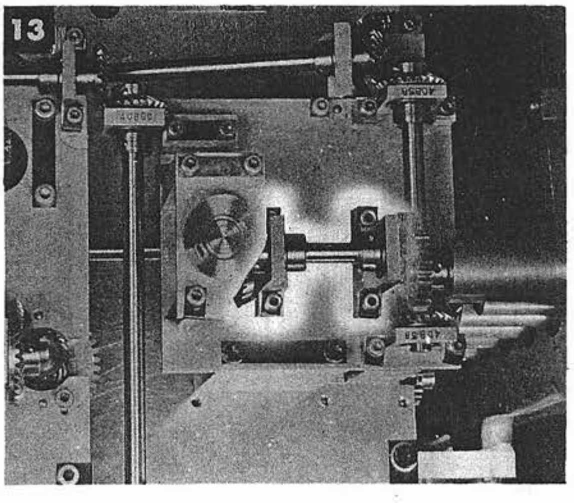
Gene Slover's US Navy Pages | Table of Contents

11 Remove the four screws securing the horizontal shaft assembly at the top of the *Dz, jDd* mounting plate.

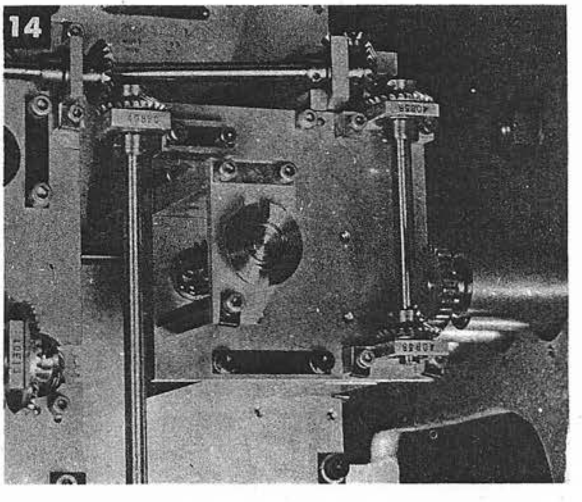


12 Remove the shaft assembly.



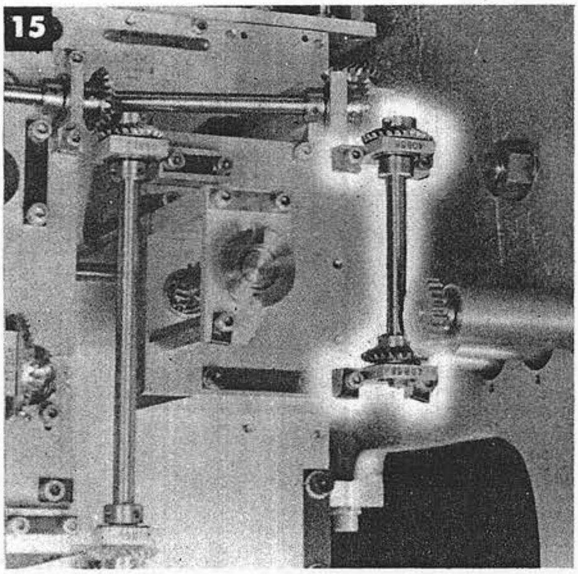


13 Remove the four screws securing the small shaft assembly in front of the *Dz* component solver.

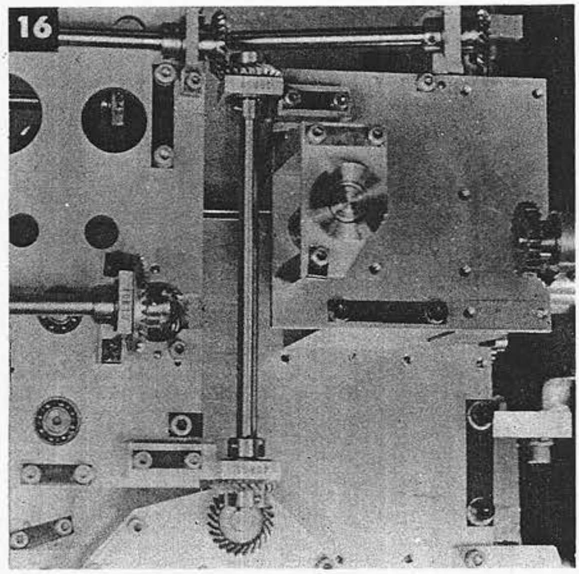


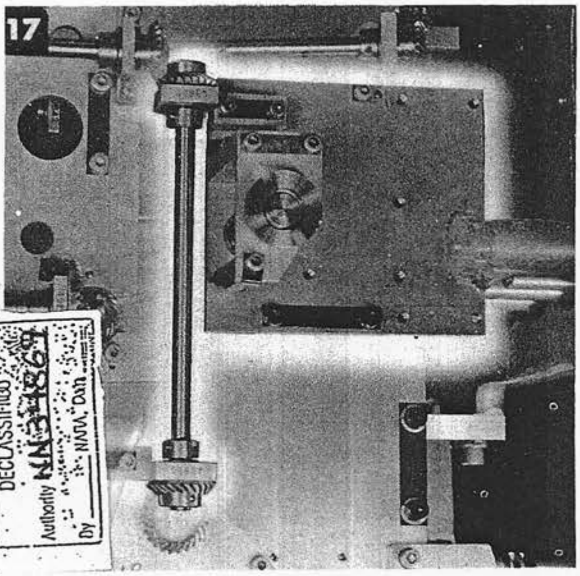
14 Tilt the shaft assembly to clear the gears and remove it.

15 Remove the four screws securing the vertical shaft assembly in front of the *Dz* component solver.

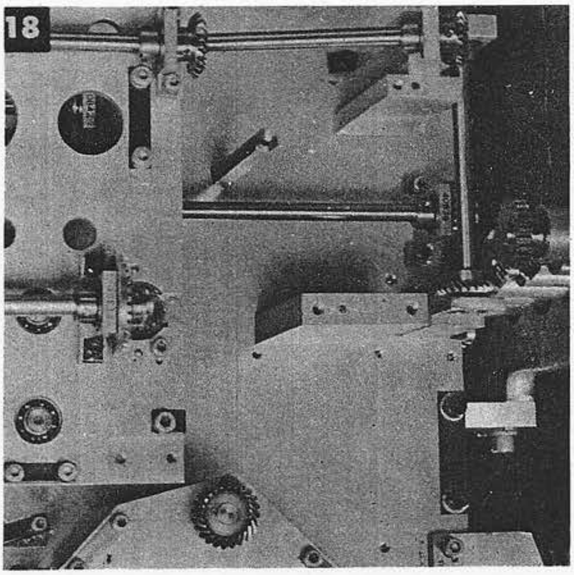


16 Remove the shaft assembly.





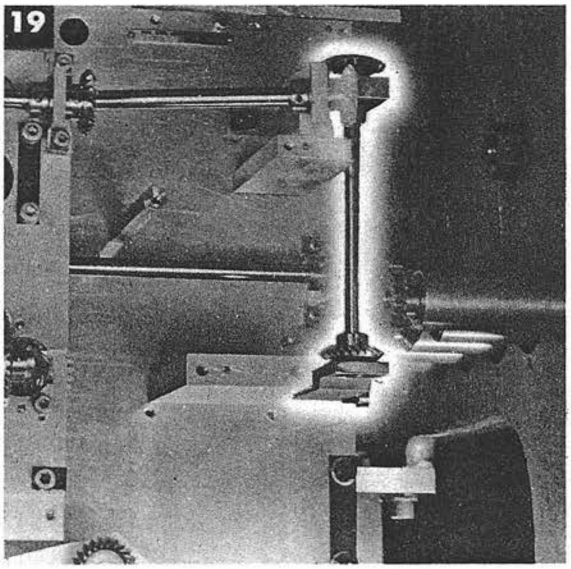
17 Remove the six screws from the plate and shaft assembly in front of the *Dz* component solver.



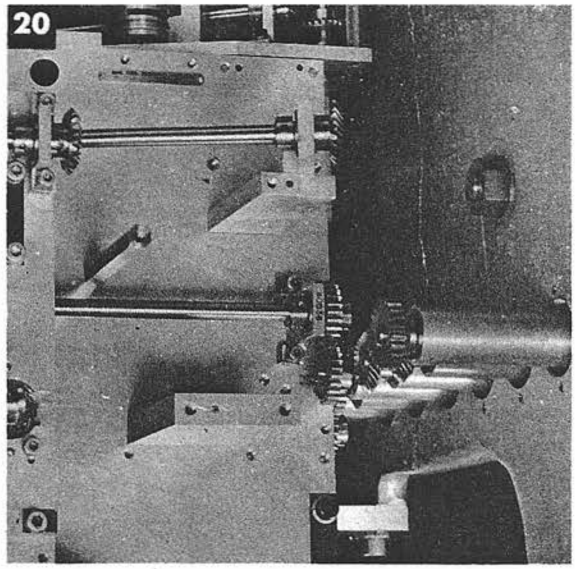
18 Work the dowels loose and remove the plate and shaft assembly.

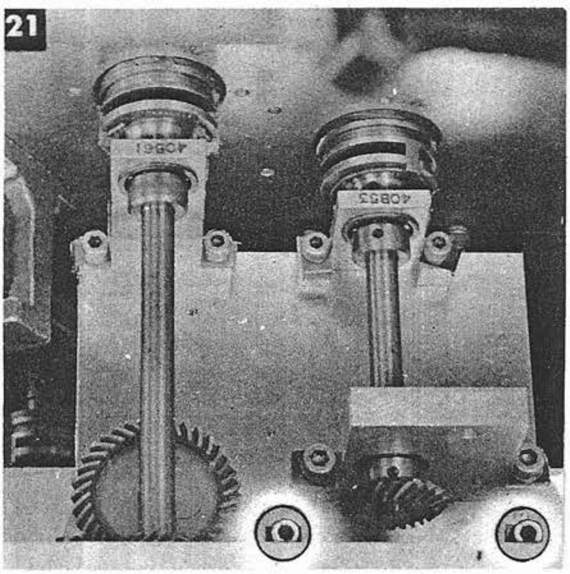
Gene Slover's US Navy Pages | Table of Contents

19 Remove the four screws securing the vertical shaft assembly in front of the *Dz* component solver.

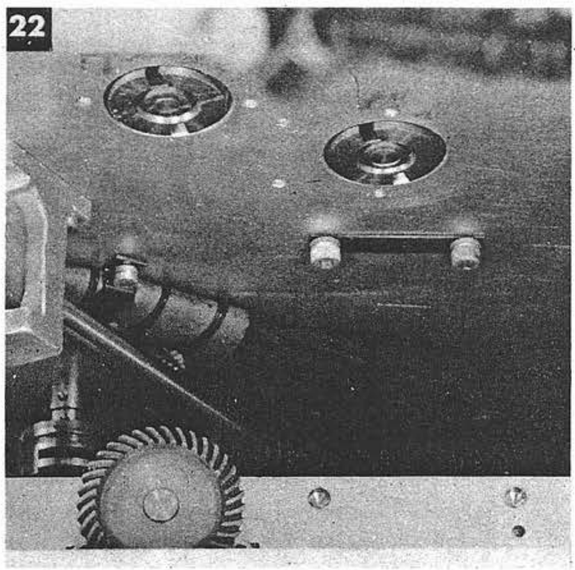


20 Remove the shaft assembly.





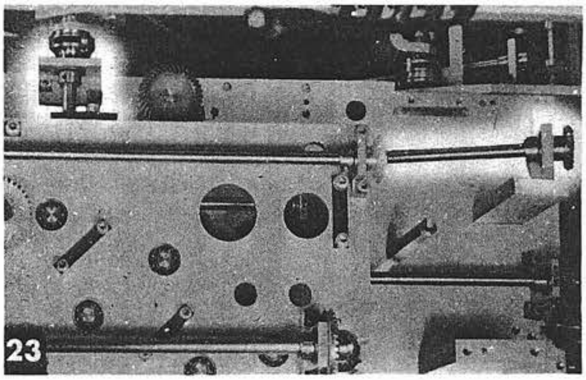
21 Remove the two screws from the small plate above the mounting plate.
Remove the two screws from the lower hanger of the longer of the shaft assemblies.

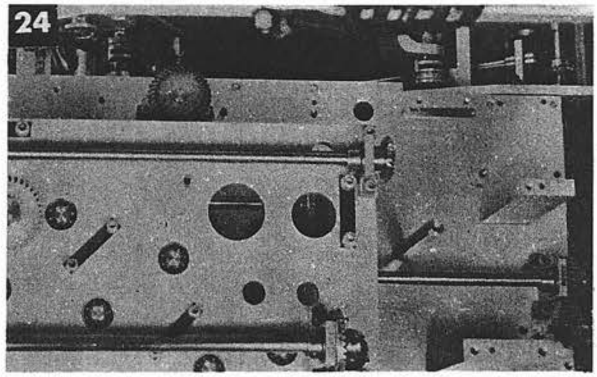


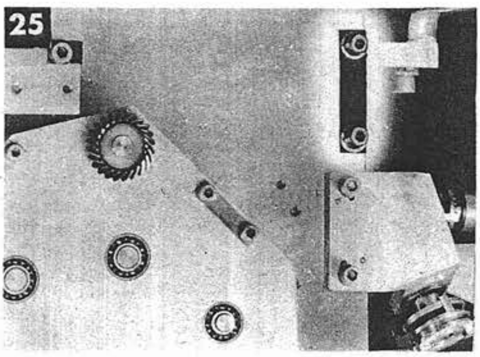
22 Work the two dowels loose. Disengage the two couplings.
Remove the plate.

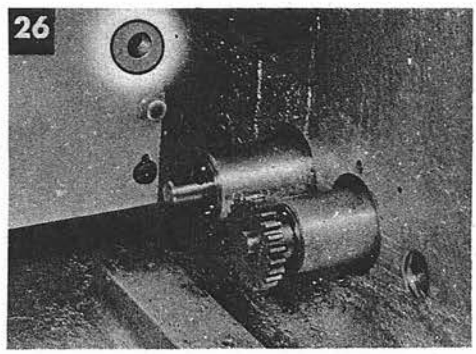
23 Remove the six screws from the shaft assembly at the top section of the *Dz, jDd* mounting plate.
Remove the locking springs from the coupling end of the assembly.

24 Remove the assembly.



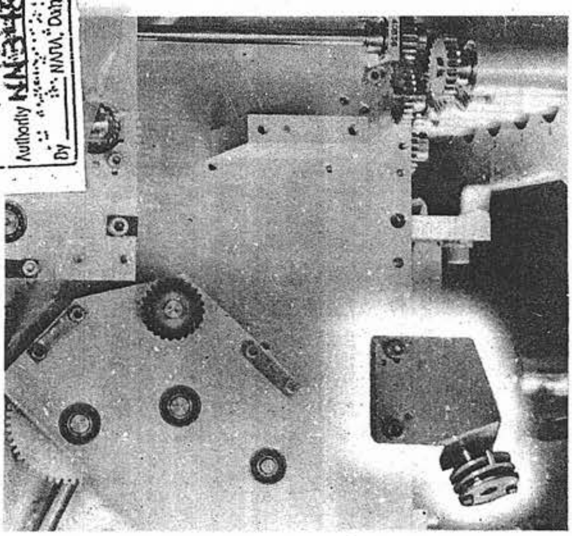




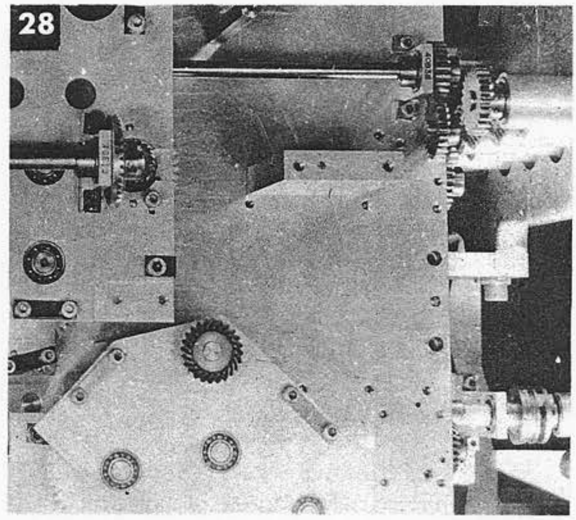


25 Remove the two screws securing the mid-section of the *Dz, jDd* mounting plate.

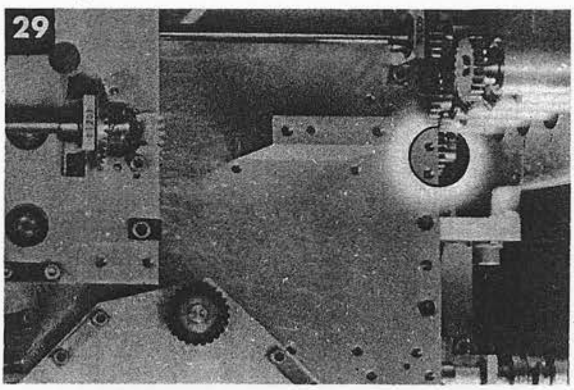
26 Remove the three screws securing the lower section of the mounting plate. One screw can be reached through the access hole in the plate.



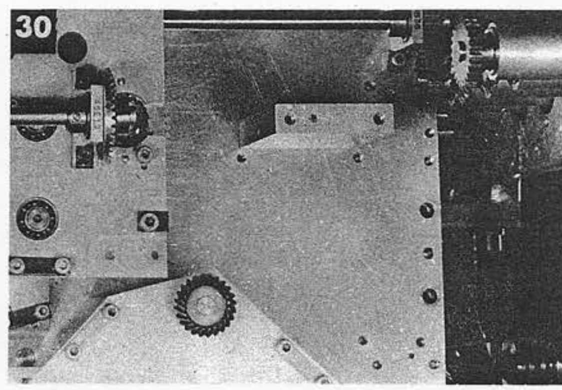
27 Remove the two screws securing the bracket of the $WrD + KRdBs$ coupling.



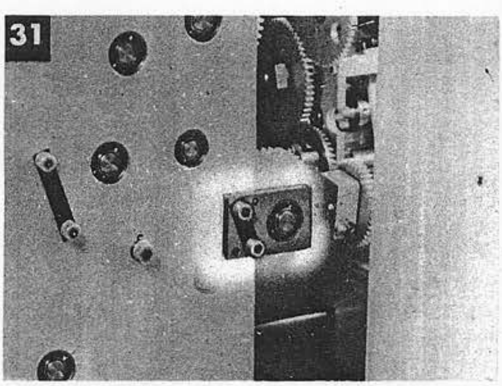
28 Work the bracket dowels loose. Remove the bracket.



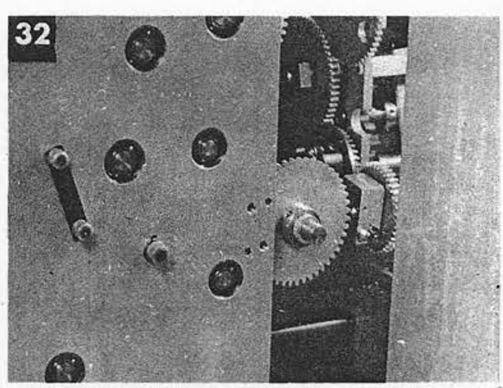
29 Unpin the spur gear at the center front of the *Dz, jDd* mounting plate.



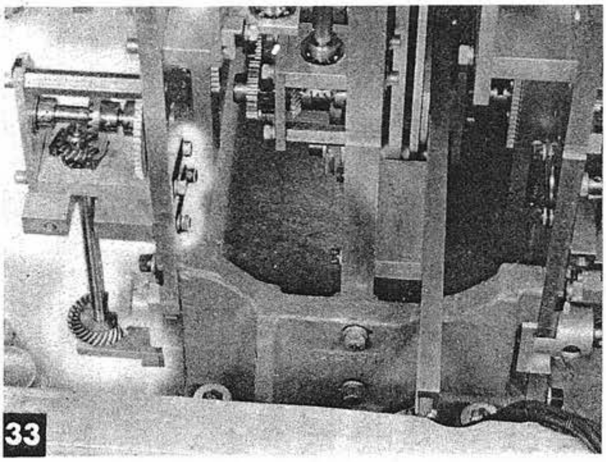
30 Remove the gear.

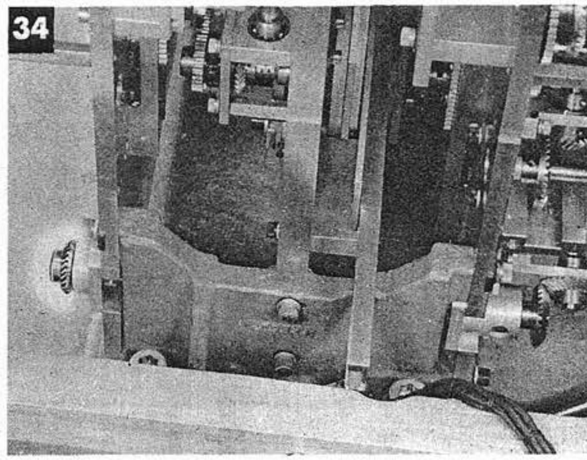


31 Remove the two screws securing the hanger of the horizontal shaft assembly with the large spur gear.



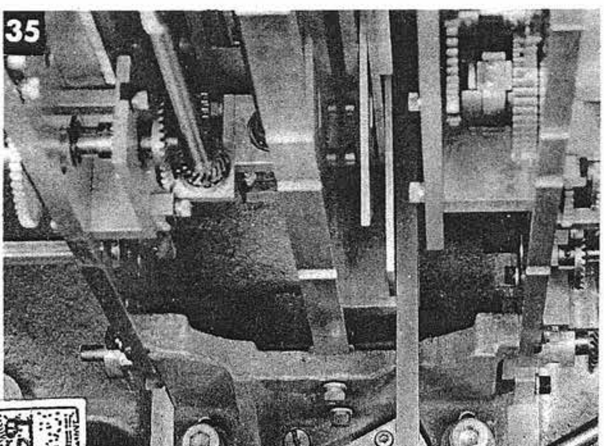
32 Work the dowels loose. Remove the hanger.

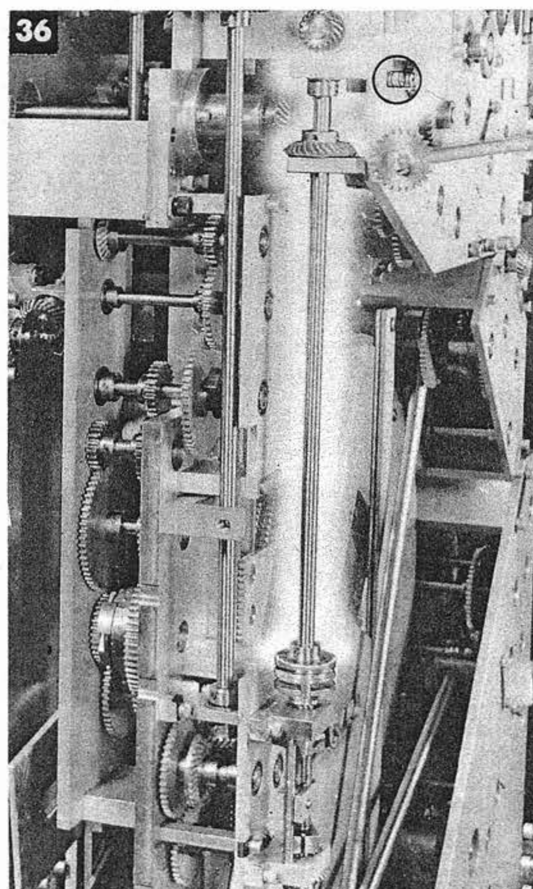




33 Remove the seven screws from the shaft assembly to the right of the deck tilt mounting plate.
Remove the shaft assembly.

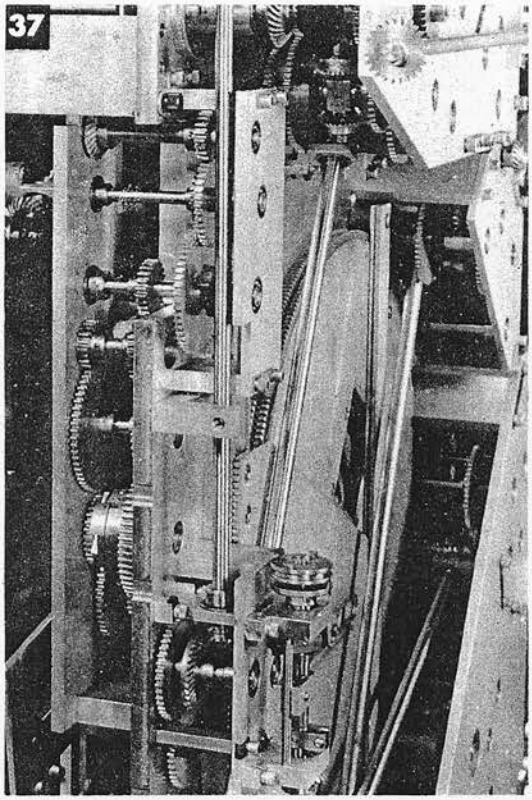
34 Unpin the bevel gear.





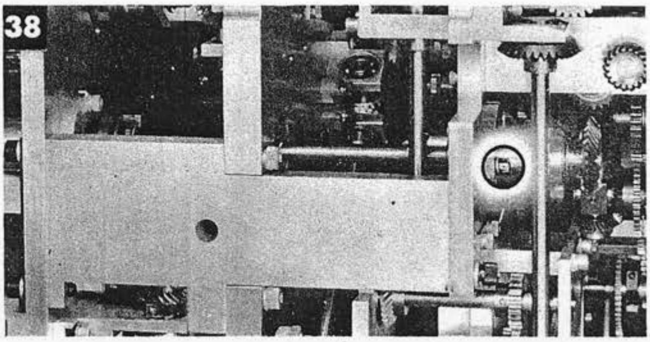
emove the gear.

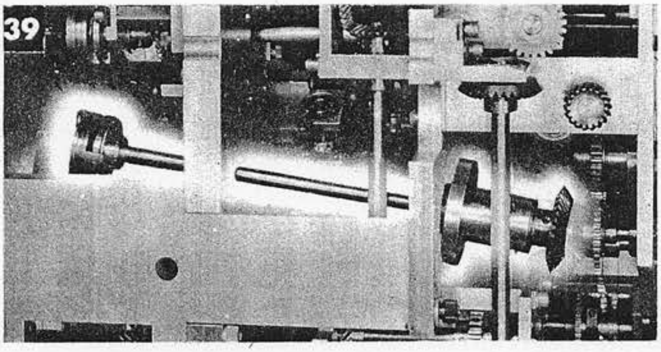
Remove the four screws securing the vertical coupling shaft near the upper rear edge of the *Dz, jDd* mounting plate.
Remove the locking spring from the coupling end of the assembly.

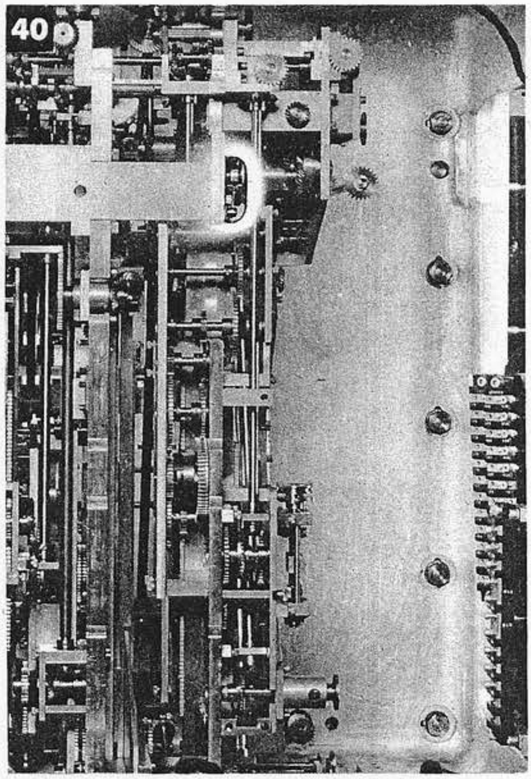


37 Remove the shaft assembly.

38 Remove the two screws securing the adapter for the shaft assembly above the *Dz* computer.

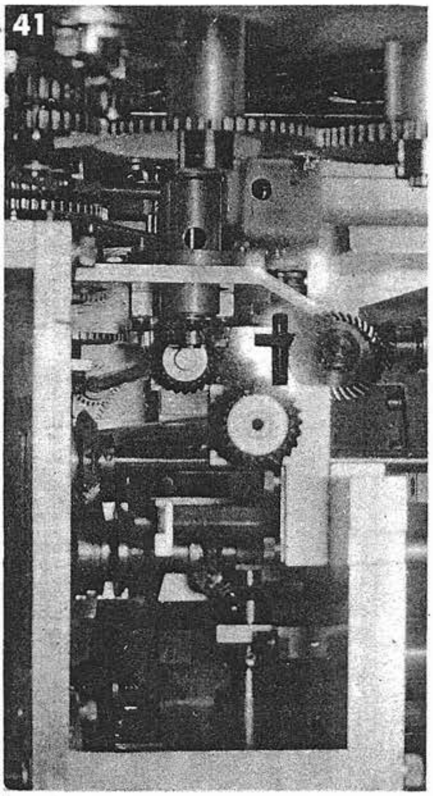


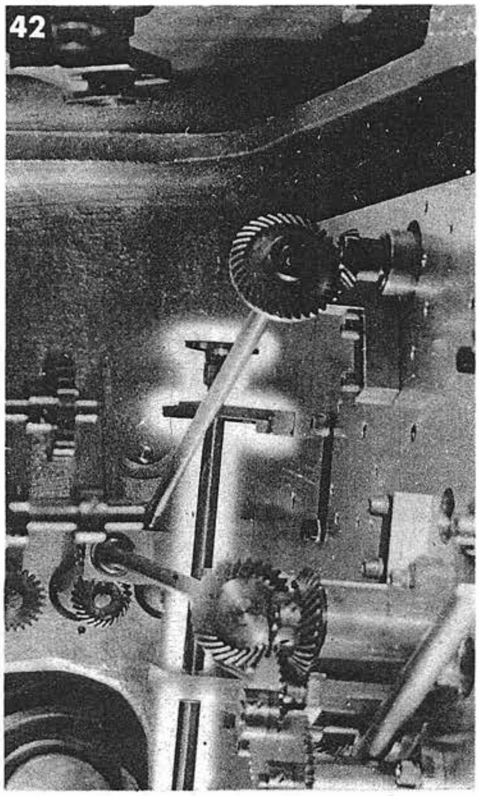




39 Slide the shaft assembly to the right as far as clearance will permit.

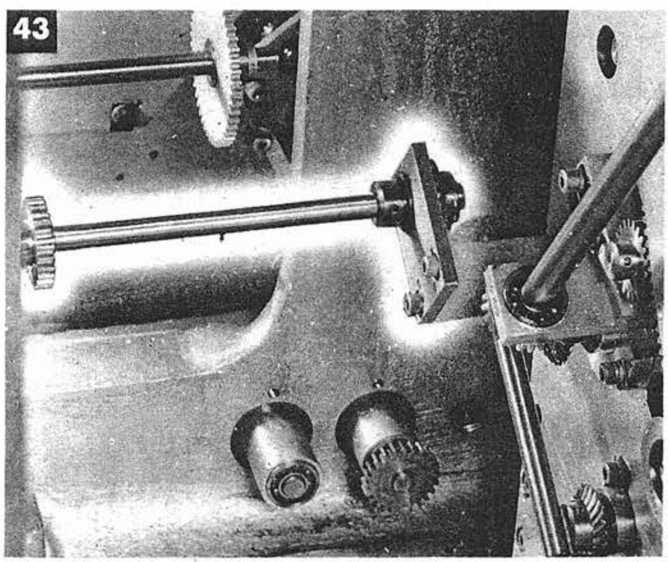
40 Remove the five screws securing the *Dz, jDd* mounting plate to the brackets.



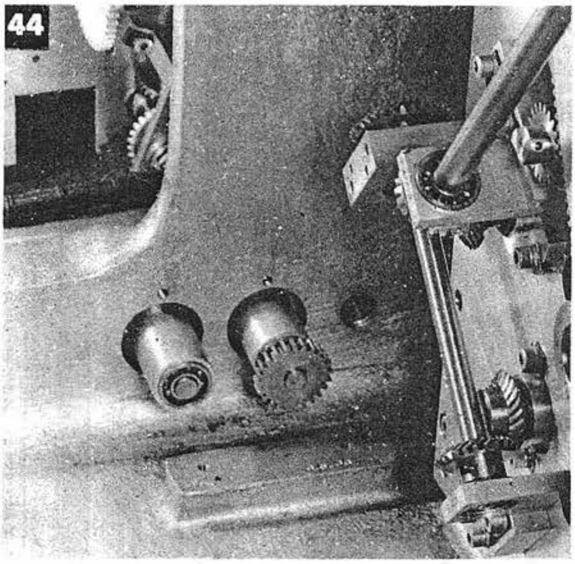


41 Work the dowels free from the brackets. Move the plate to gain access to the two screws securing the coupling shaft assembly at the inner edge of the plate. Remove these two screws.

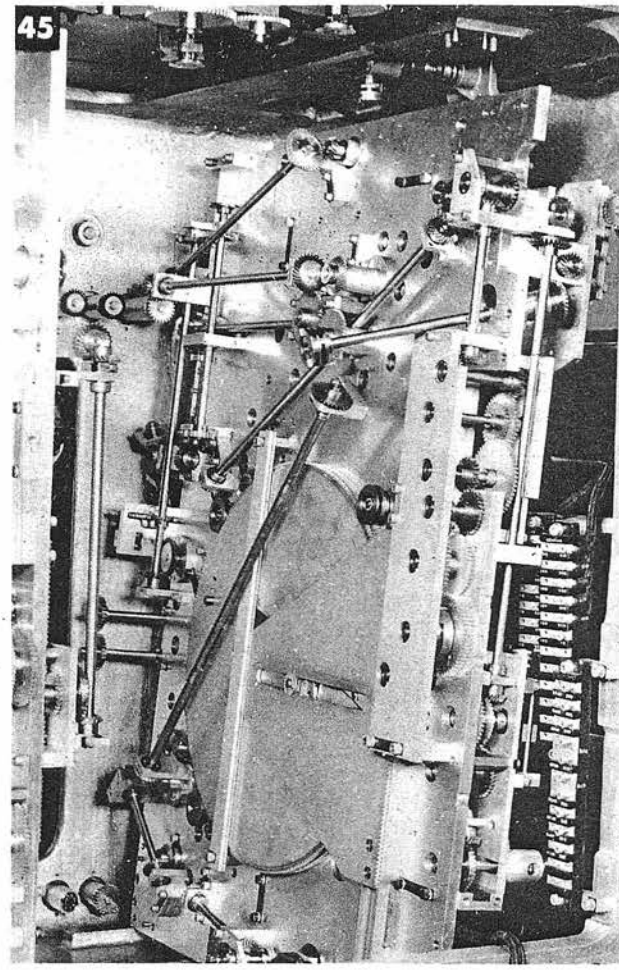
42 Slide the shaft assembly downward to clear the hole in the upper plate. Move the *Dz, jDd* mounting plate out still farther.



43 Remove the two screws securing the horizontal shaft assembly at the lower inner edge of the mechanism.



44 Remove the shaft assembly.



45 Move the *Dz, jDd* mounting plate to the outer edge of the computer case to gain access to the inner mechanism. It is not practical to remove the plate from the instrument.

Disconnect the power leads from the *Dd, jB'r,* and *Vz* follow-ups.

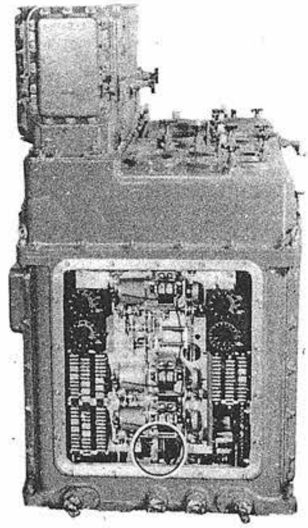
Loosen the following adjustment clamps: A-116, A-198, A-184, A-500, A-501, A-234, A-235, A-86, A-87, A-88, A-212, A-89, A-96, A-55, A-77, A-260, A-250, A-210, A-146, A-145, A-147, A-183, A-180, A-30, A-29, A-31, A-8, A-99, A-28, A-58, A-243, A-49, A-52, A-156, A-3, A-226, A-227, A-228, A-90, A-91, A-12, A-259, A-60, A-35, A-216, A-112, A-208, A-113, A-63, A-36, A-215, A-33, A-34, A-61, A-32, A-111, A-64, A-65, A-57, A-199, A-62, A-92, A-5, A-51, A-98, A-70, A-50, A-179, A-230, and A-17 (star shell computer).

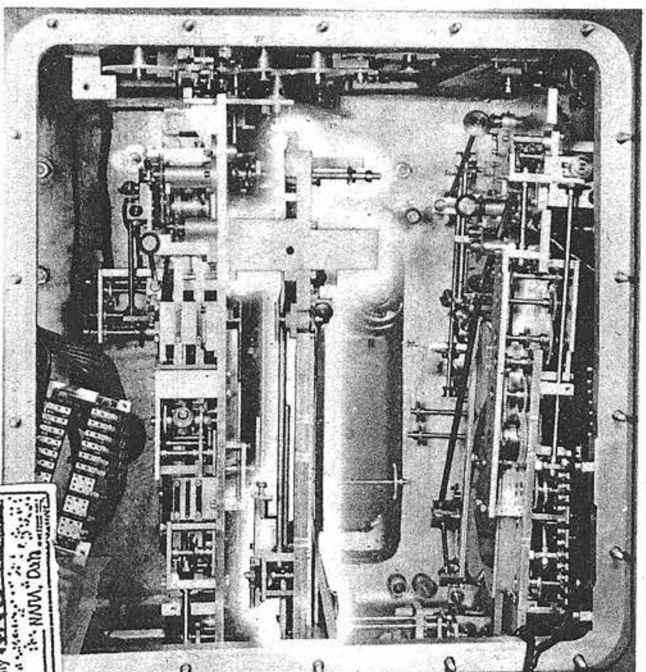
Readjust the clamps in the order given above.

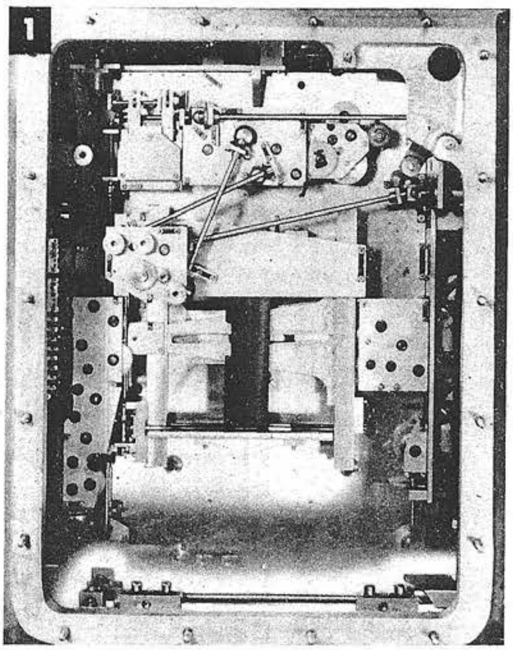
Run all tests.

Zd² tan (Eb + Vs) AND Zd • Ds MULTIPLIERS

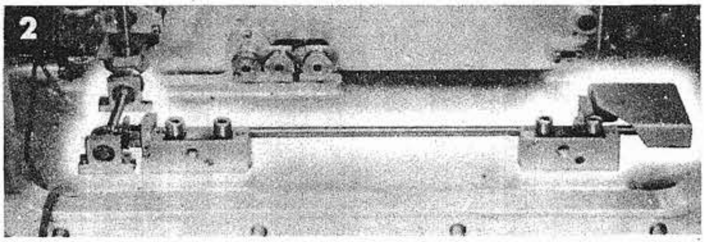
Co Receiver, page 666
Dd Follow-up, page 775
jB'r Follow-up, page 776
Vz Follow-up, page 777
Dd, jB'r, Vz Mounting Plate, page 778
B'r Receiver, page 765
B'gr Indicating Transmitters, page 766
B'gr Automatic Transmitters, page 767
B'r, B'gr Mounting Plate, page 768
Eb Receiver, page 755
E'g Indicating Transmitters, page 757
E'g Automatic Transmitters, page 758
Eb, E'g Mounting Plate, page 762
jDd and *Dz,* Computers, page 780

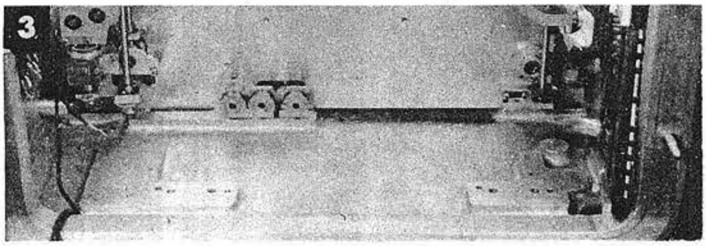




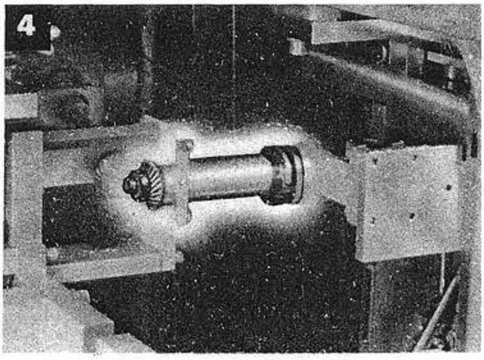


1 Remove the four screws securing the two mounting blocks to the floor of the computer. Remove the blocks.
Remove the six screws securing the long shaft assembly on which clamp A-58 and limit stop L-16 are mounted. Remove the assembly.
Remove the four screws securing the shaft assembly which connects with the long shaft just removed.
Remove the assembly.

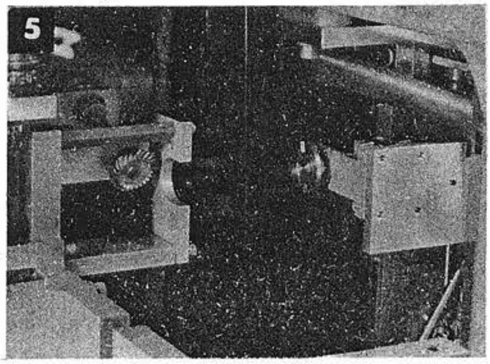




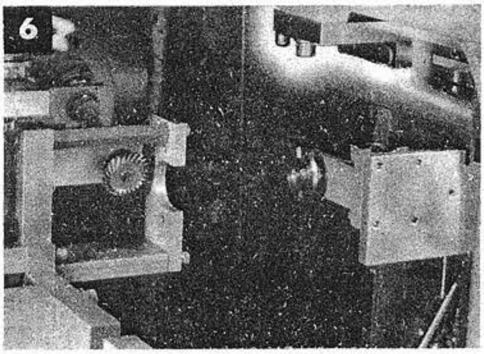
4 Remove the locking spring from the coupling end of the shaft assembly between the two halves of the computer. Remove the two screws securing the adapter.

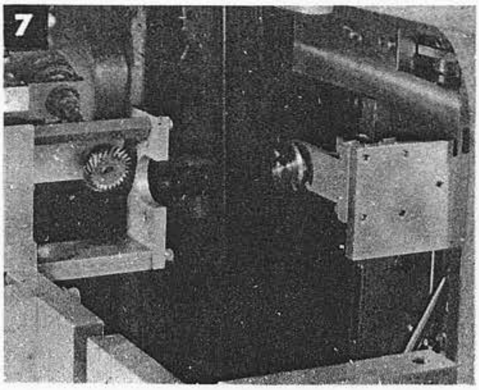


5 Remove the assembly.

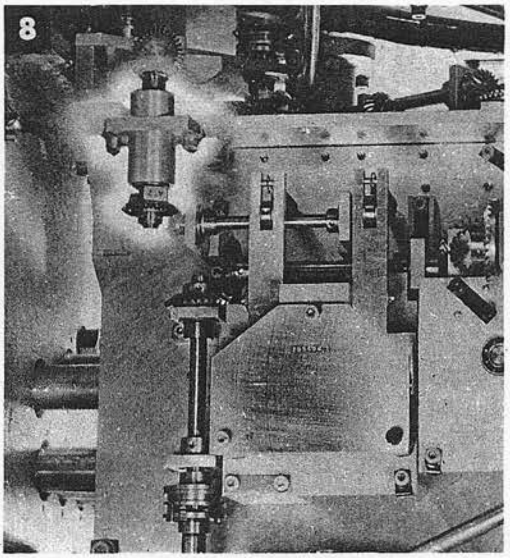


6 Remove the four screws from the angle bracket securing the Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ multipliers mounting plate above the shaft assembly just removed.

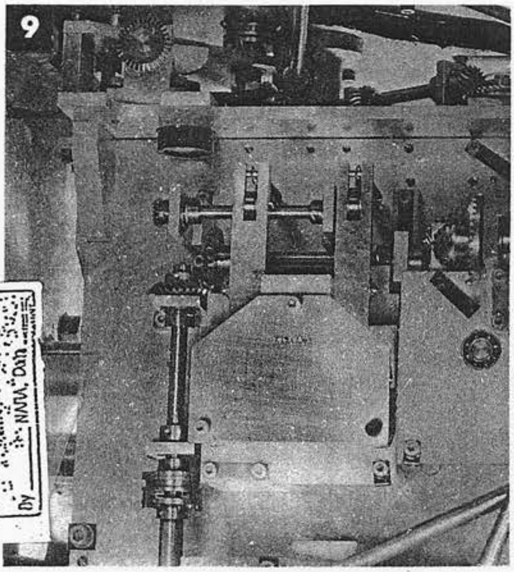




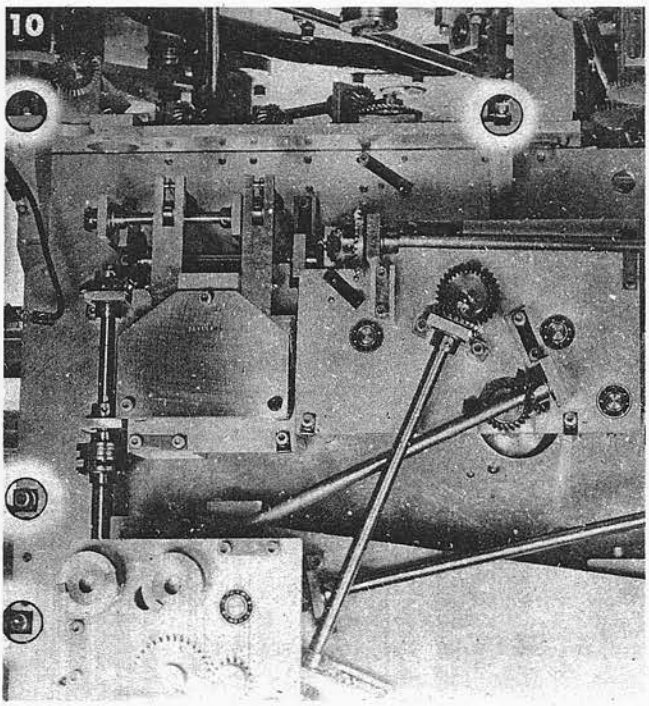
7 Work the dowels free. Remove the bracket.



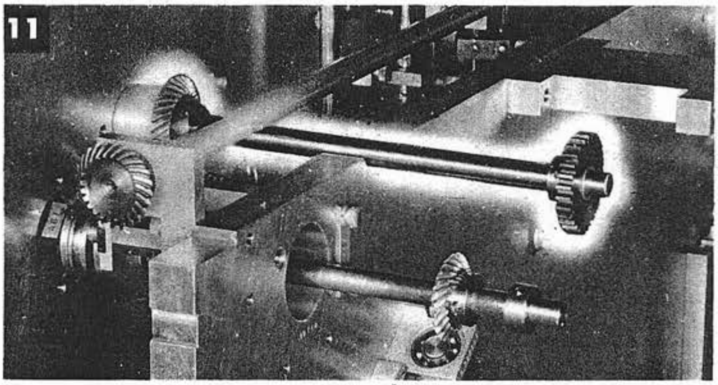
8 Remove the two screws securing the adapter of the shaft assembly on which clamp A-12 is mounted.



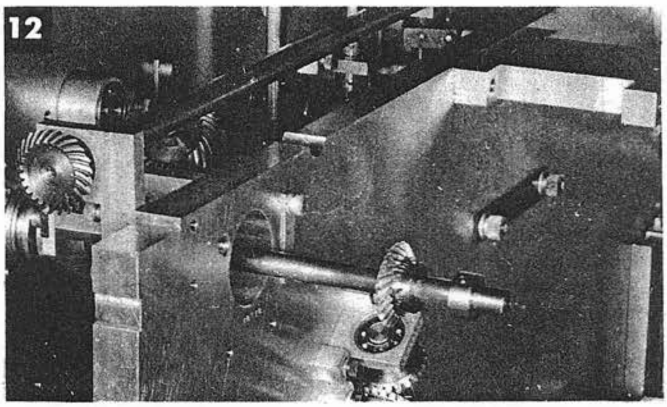
9 Remove the assembly.



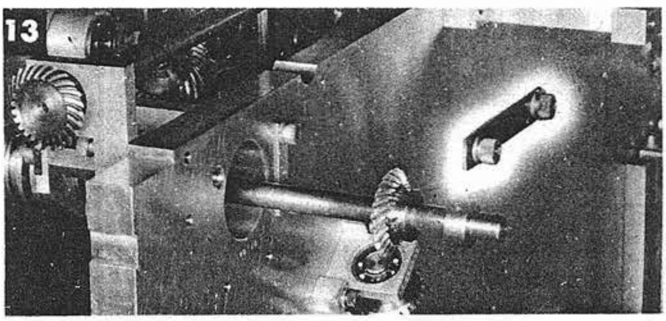
10 Remove the two screws securing the top plate. Remove the two screws securing the middle of the deck tilt mounting plate.



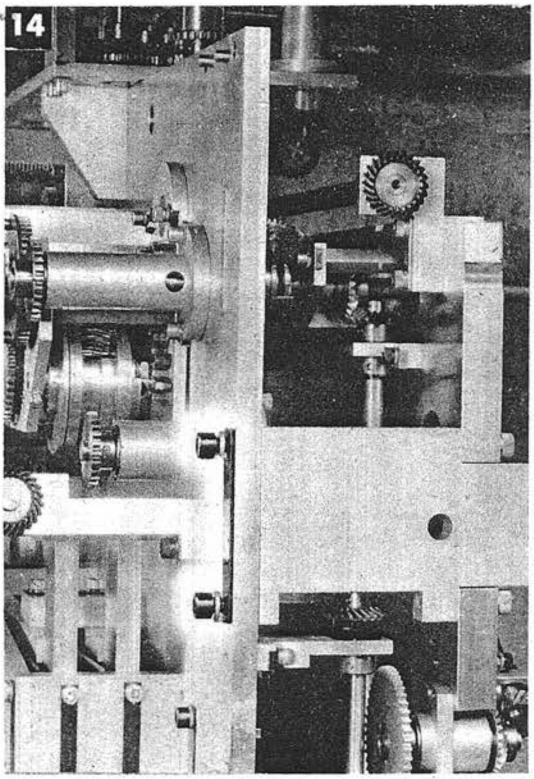
11 Remove the two screws securing the adapter of the shaft assembly over the Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ multiplier mounting plate.
The screws are on the deck tilt mounting plate.



12 Remove the shaft assembly.



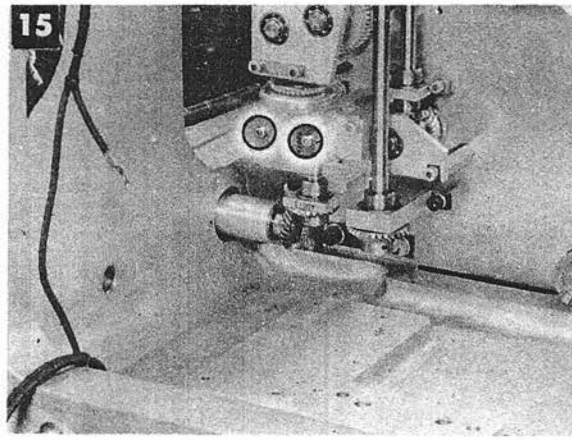
13 Remove the two screws securing the Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ multiplier mounting plate.



14

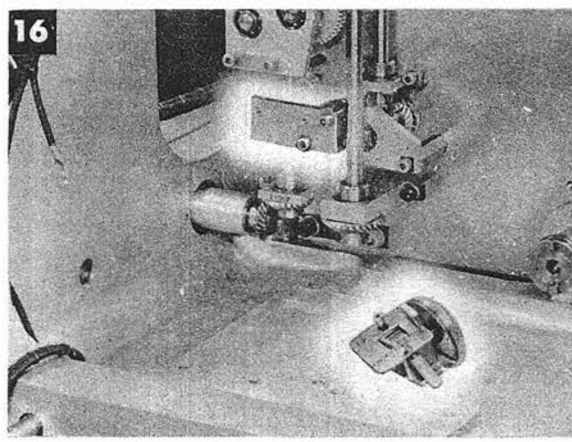
14 Remove the two screws securing the deck tilt mounting plate to a support at the top rear. The support remains on the $Zd^2 \tan (Eb + Vs)$ and $Zd \cdot Ds$ plate.

15 Remove the two screws securing the *E2* counter.



15

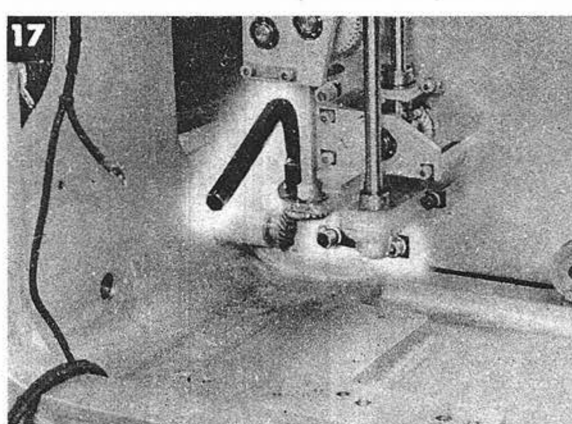
16 Remove the counter. Remove the two screws securing the supporting bracket. Remove the bracket.



16

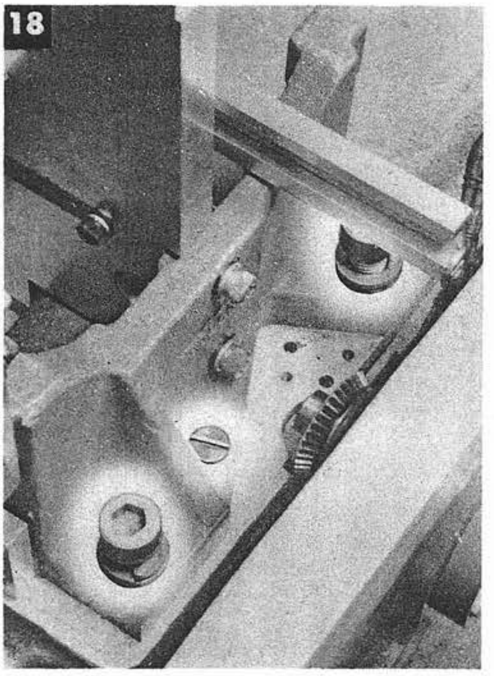
17 Remove the screw dowel and the two screws securing the front bracket to the floor of the computer.

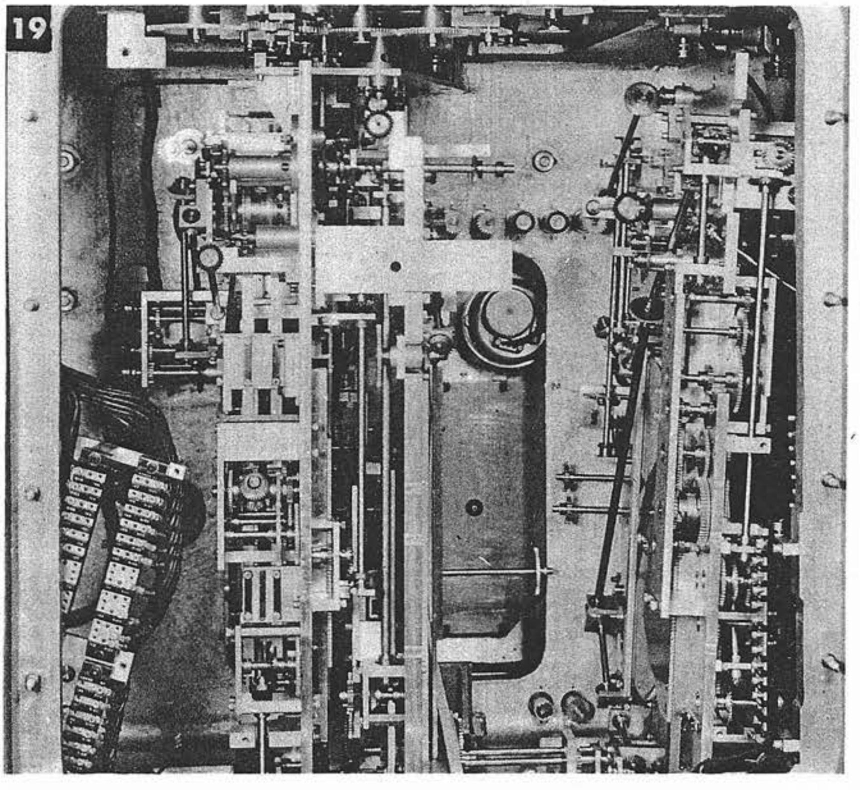
Remove the two screws securing the deck tilt mounting plate to the bracket.



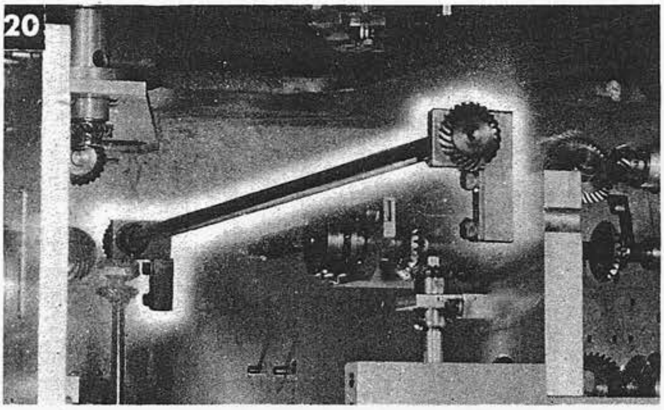
17

18 Loosen the screw dowel. Remove the two large screws securing the front bracket of the Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ multiplier mounting plate to the floor of the computer.

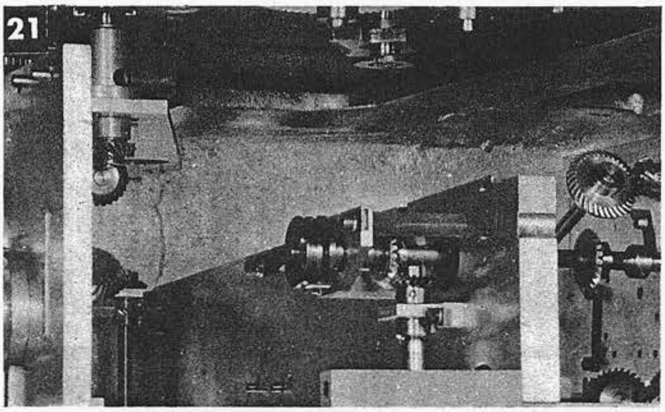




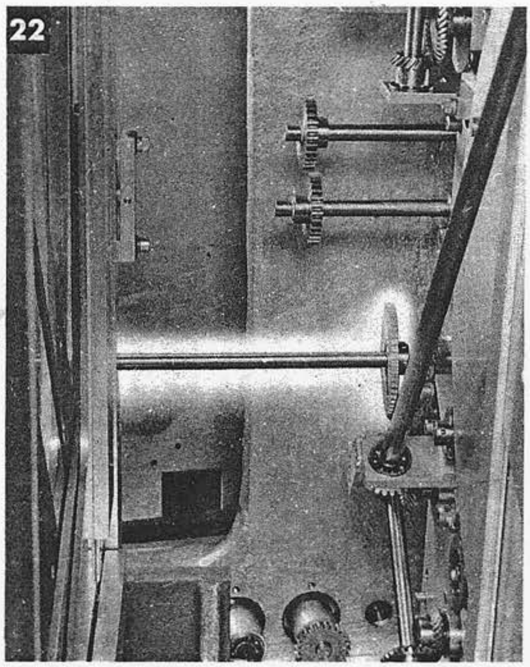
19 Move the Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ multiplier mounting plate a few inches.



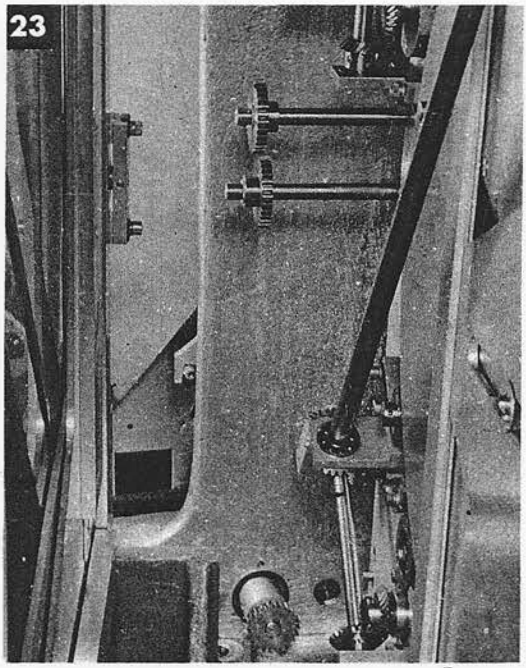
20 Remove the four screws securing the long shaft assembly at the top of the Zd^2 tan $(Eb + Vs)$ and the $Zd \cdot Ds$ multiplier mounting plate.



21 Remove the shaft assembly.

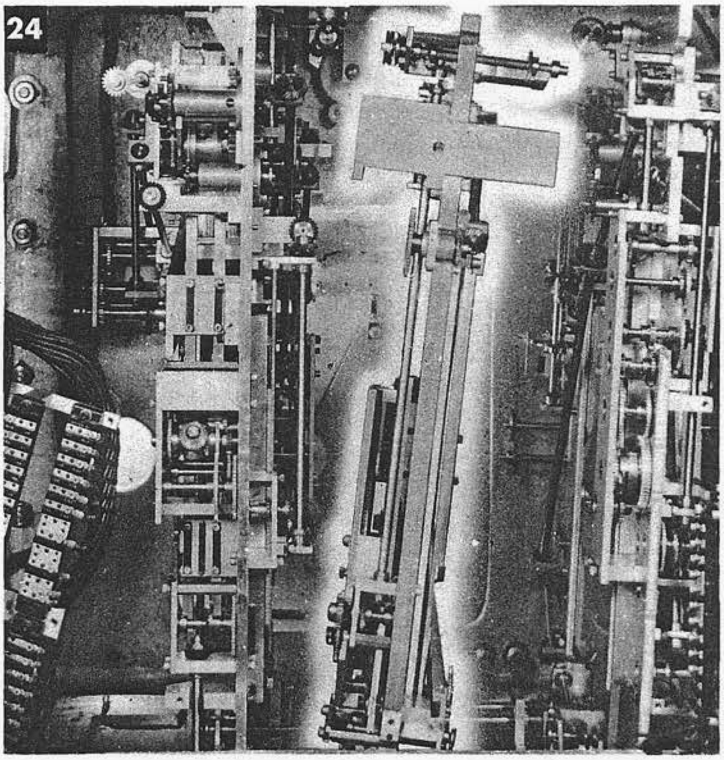


22 Remove the two screws from the hanger supporting the shaft assembly at the inner edge of the Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ multiplier mounting plate.

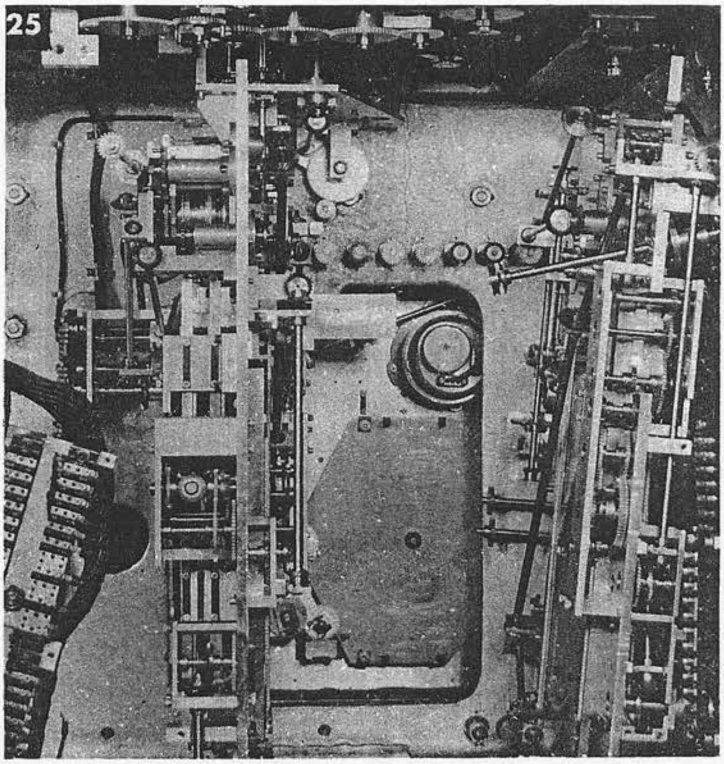


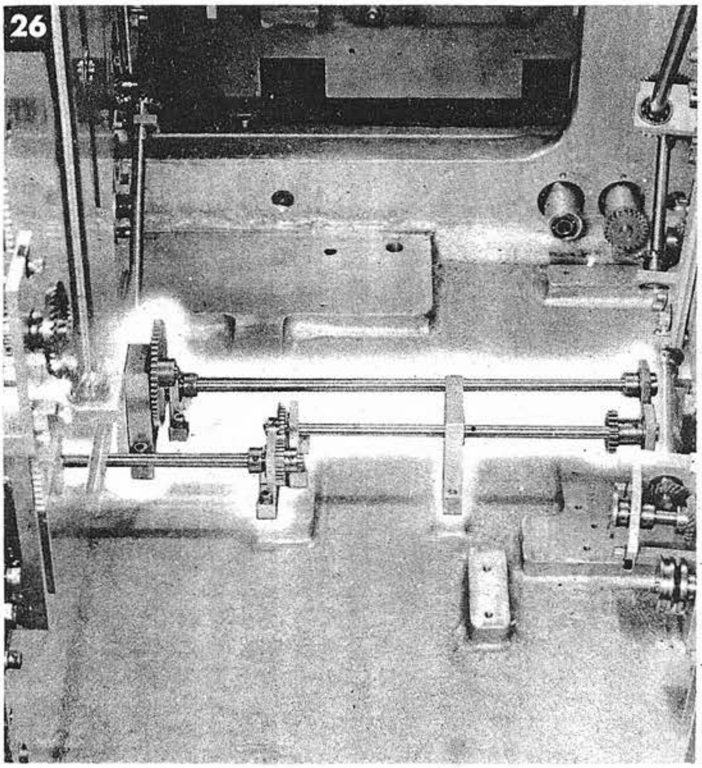
23 Remove the shaft assembly.

24 Move the Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ multiplier mounting plate to the right.

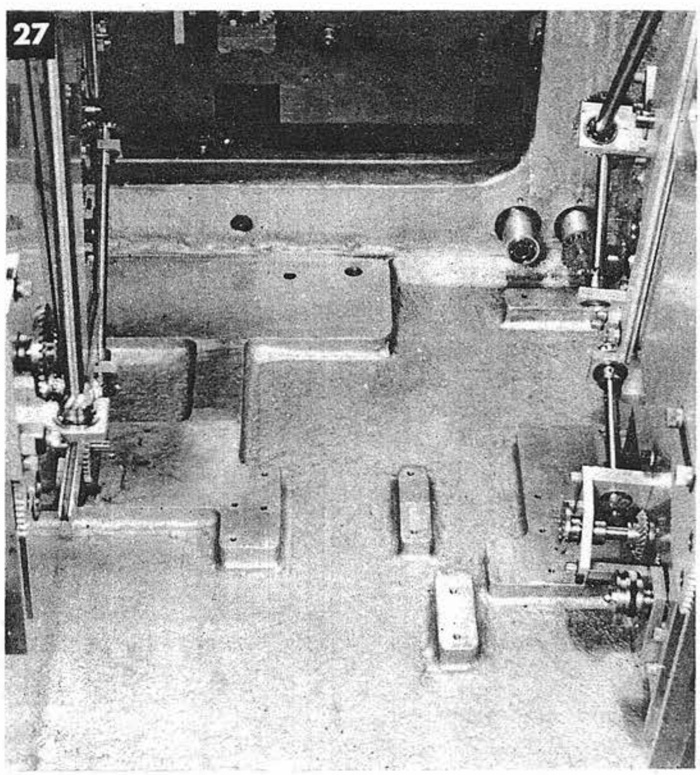


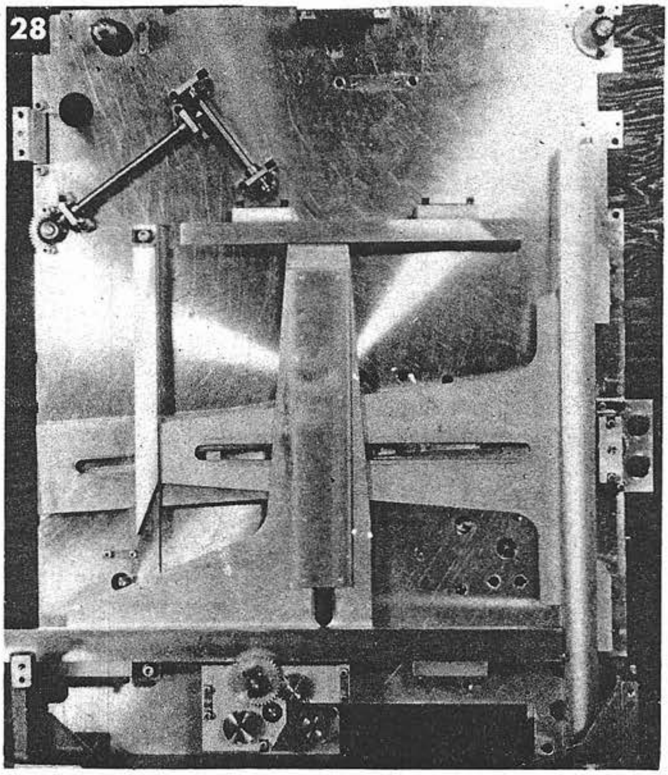
25 Remove the plate.





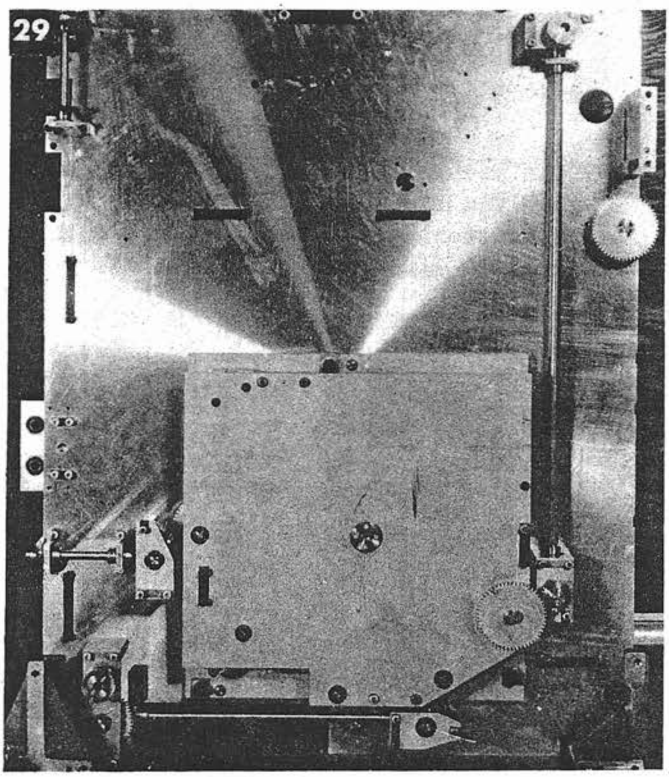
26 To provide additional clearance for working on the deck tilt component solver, remove the gearing at the floor of the computer.





28 The $Zd \cdot Ds$ multiplier in position for repair.

29 The Zd^2 tan $(Eb + Vs)$ multiplier in position for repair.



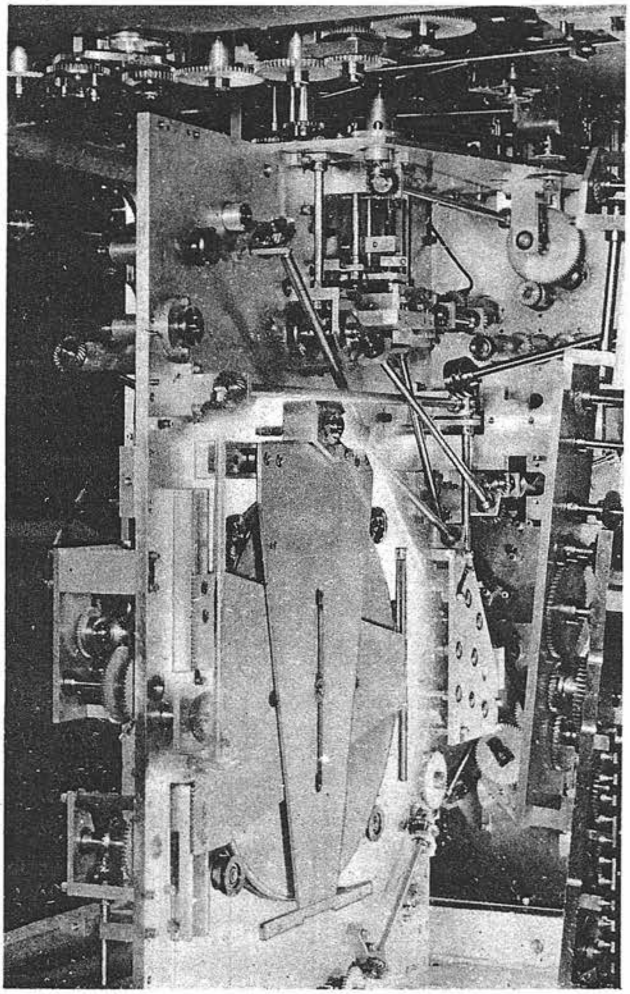
To reinstall these mechanisms, reverse the removal procedure.

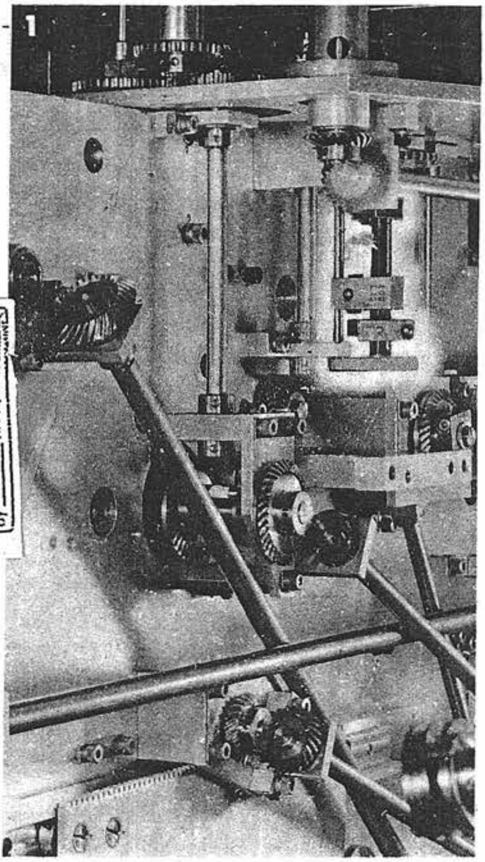
Reinstall the other mechanisms removed.

For readjustment procedure, follow the directions given on page 791.

DECK TILT COMPONENT SOLVER, LIMIT STOP L-12

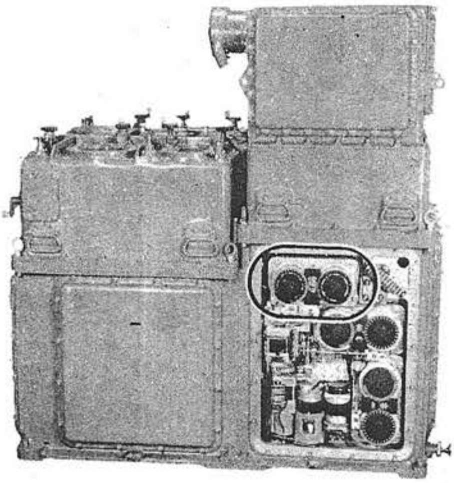
Co Receiver, page 666
Dd, jB'r, and *Vz* Follow-up Mounting Plate, page 778
B'r Receiver, page 765
B'gr Indicating Transmitters, page 766
B'gr Automatic Transmitters, page 767
B'r, B'gr Mounting Plate, page 768
jDd and *Dz* Computers, page 780
Eb Receiver, page 755
E'g Indicating Transmitters, page 757
E'g Automatic Transmitters, page 758
Eb, E'g Mounting Plate, page 762
Zd^2 tan $(Eb + Vs)$ and $Zd \cdot Ds$ Multipliers, page 792





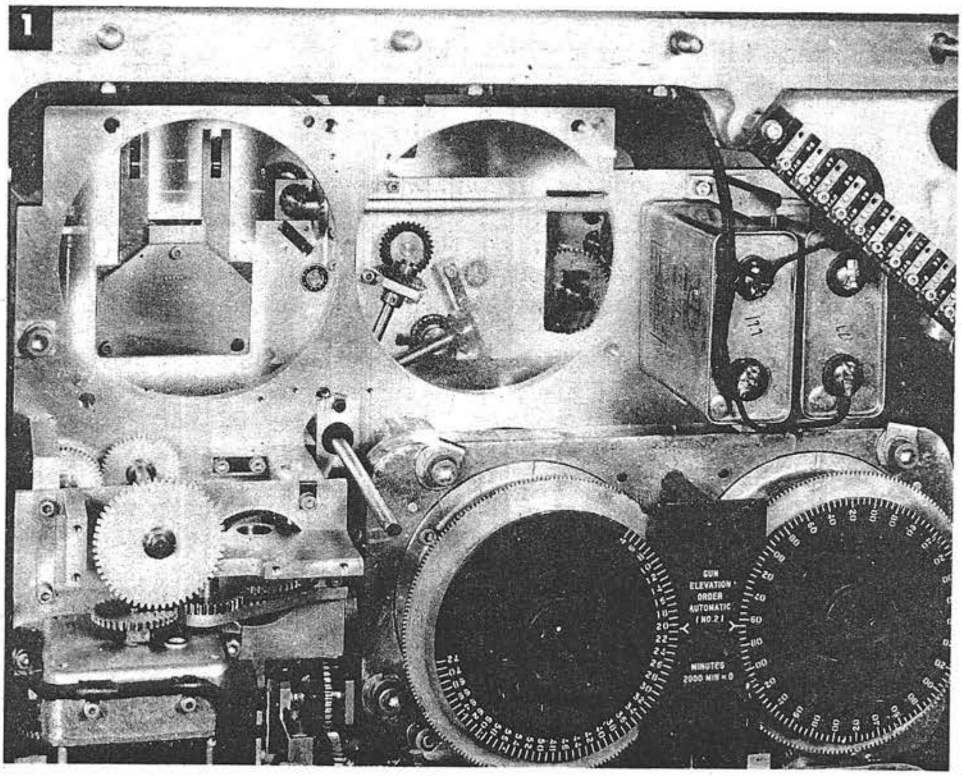
1 Work can be done on the deck tilt component solver, limit stop L-12, and the associated gearing without removing them from the instrument.

For the readjustment procedure, follow the directions given on page 791.



$Eb + Vs$ INTERMITTENT DRIVE SYNC E BRAKES

Parallax Transmitters, page 760



1 The $Eb + Vs$ intermittent drive and the sync E brakes are on the same side of the deck tilt mounting plate as the $L \cdot L \sin 2B'r$ and $Zd\ (L - L \cos 2B'r)$ multipliers.
The $Eb + Vs$ intermittent drive and the sync E brakes can be reached for repairs through the access allowed by the removal of the parallax transmitters.

After work has been completed on the $Eb + Vs$ intermittent drive, reinstall the parallax transmitters.

Readjust clamps A-60, A-61, A-32, A-52, and A-228.

Star Shell Computer

This chapter applies to the Star Shell Computer Mark 1 Mod O. It contains instructions for removing the *Ct* indicator, the star shell range spot receiver, the star shell multiplier section, and the star shell gun order transmitters. All of these assemblies can be removed from the star shell computer case while it is in place on Computer Mark 1.

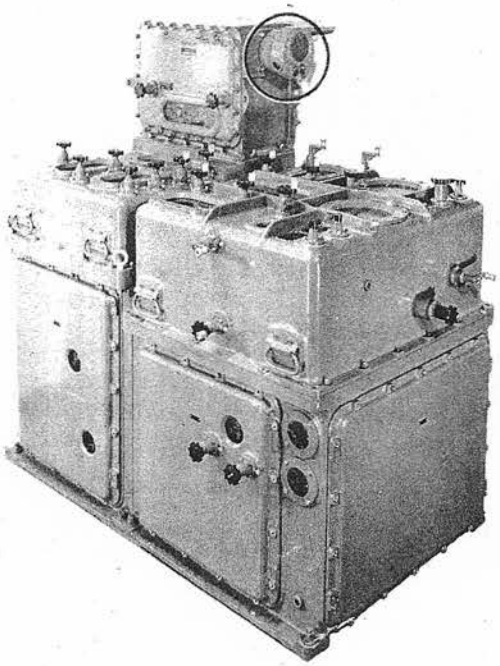
If it is necessary to remove the entire star shell computer as a unit, either for bench overhaul or to allow removal of cover 2 from the Computer Mark 1, proceed as follows:

1. Remove the *Ct* indicator. Refer to page 805.
2. Remove the junction box cover. Disconnect all of the ship's wiring from the star shell computer terminal blocks.
3. Remove the two screws securing the cable elbow tube. Withdraw the cable from the junction box.
4. Remove the acorn nuts, lock washers, and cover washers from the fifteen studs securing the star shell computer to cover 2.
5. Insert a screw driver into each undercut in its base and pry the star shell computer loose gradually until it is free on the studs.
6. Put two 3/4-inch-diameter by 5-foot-long steel rods through the holes in the lifting brackets at the ends of the star shell computer, and use them to lift it from cover 2. It is advisable to use four men for the lifting job.

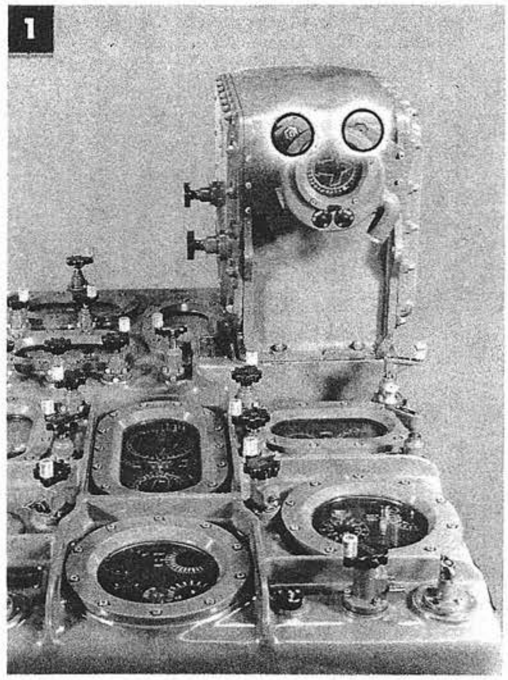
While it is on the bench, the star shell computer should be supported on blocks at either end in order to avoid damage to the dowels or mechanism on the bottom of the unit.

To reinstall the unit, reverse the removal procedure. Before tightening the securing nuts, check that the four couplings below the unit are properly aligned for engagement. After the nuts are tight, check that the couplings are engaged, and drive properly.

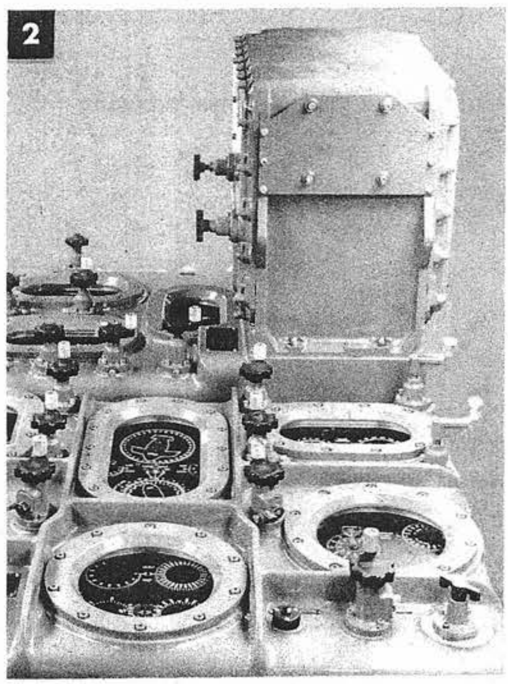
Readjust A-17, A-18, A-230, and A-231.



Ct INDICATOR



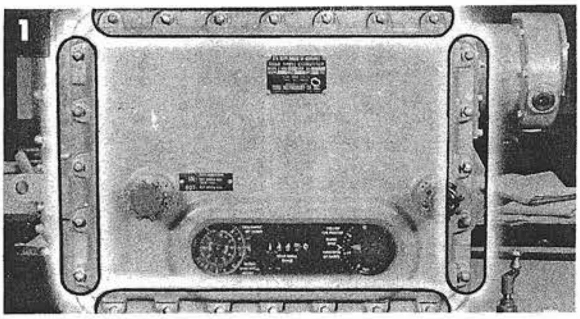
1 Loosen the four screws securing the *Ct* indicator.



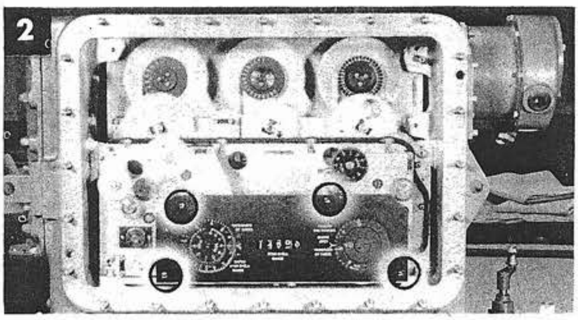
2 Remove the indicator.

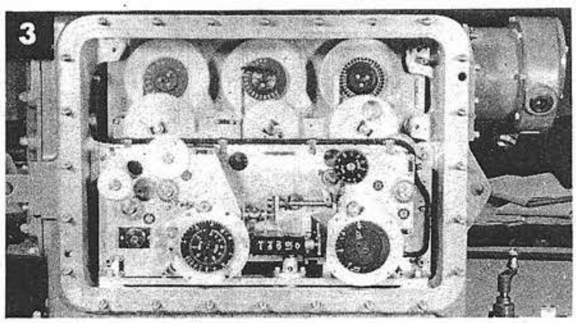
To reinstall the *Ct* indicator, reverse the removal procedure.

Rjn RECEIVER MOTOR



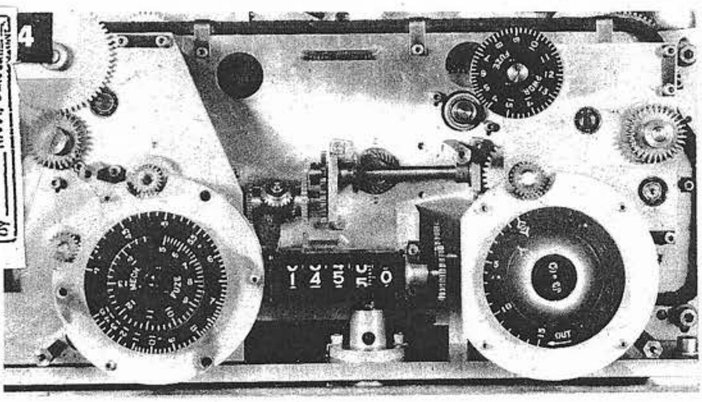
1 Remove the twenty-four acorn nuts securing the computer cover. Remove the cover.



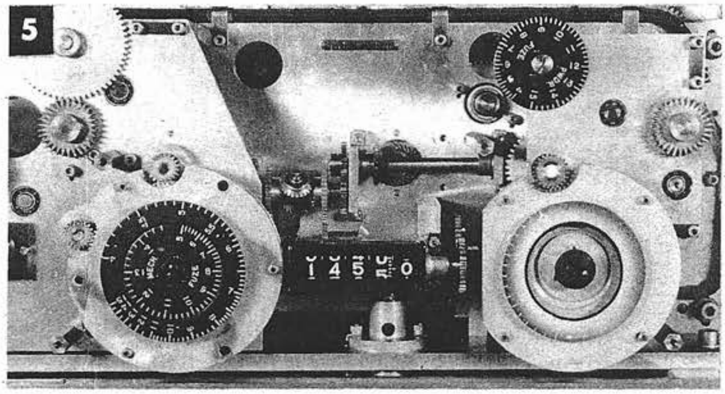


2 Remove the four screws securing the mask.

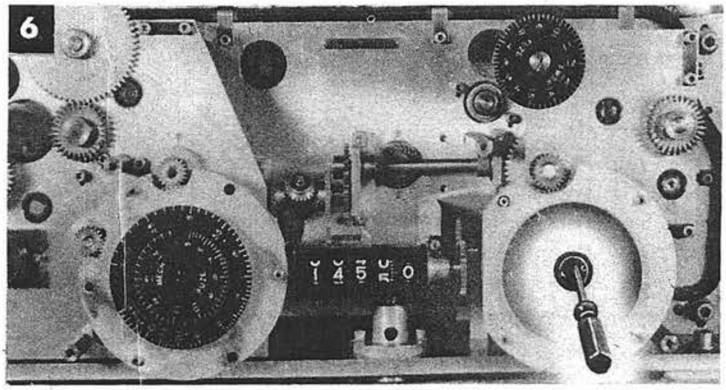
3 Remove the mask.



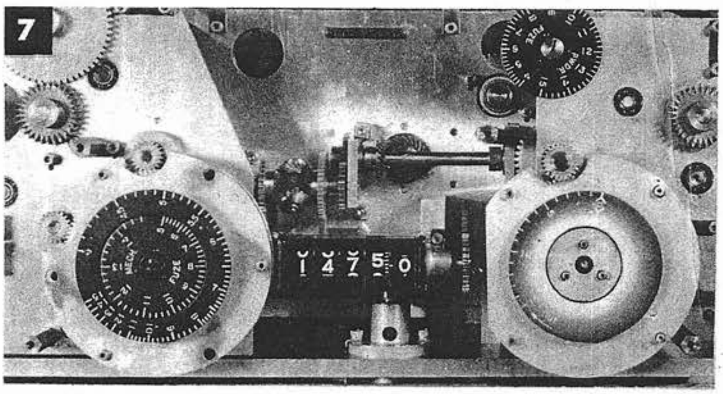
4 Remove the two screws from the dial clamp plate.



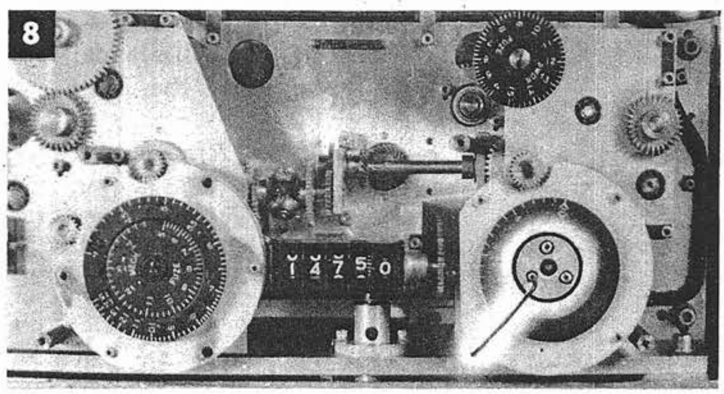
5 Remove the inner dial.



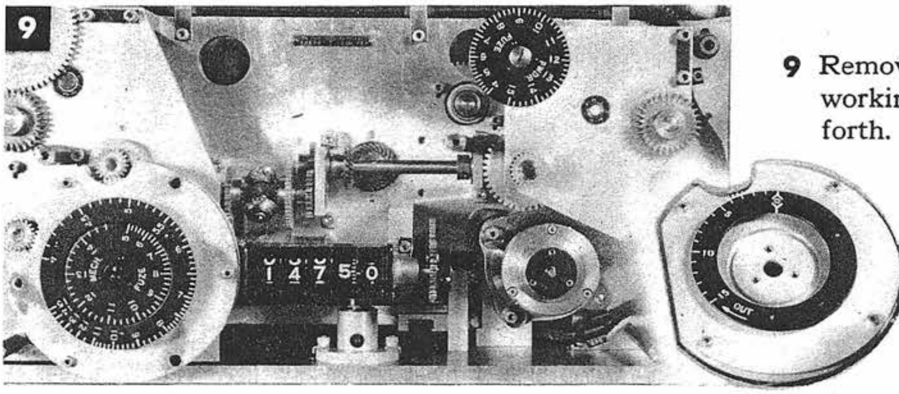
6 Using a screw driver, loosen the nut securing the dial hub to the motor shaft.



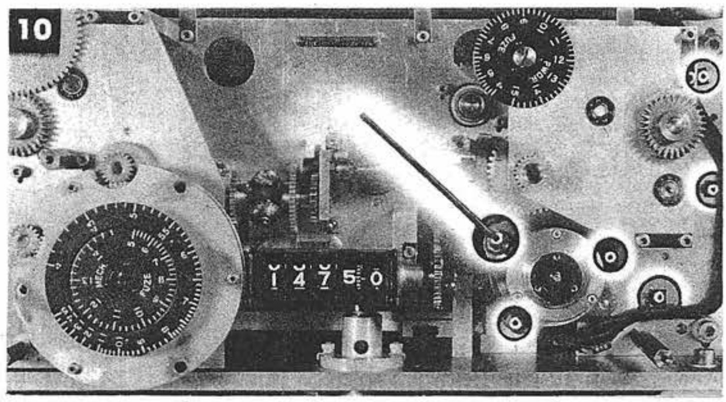
7 Remove the nut and the hub.



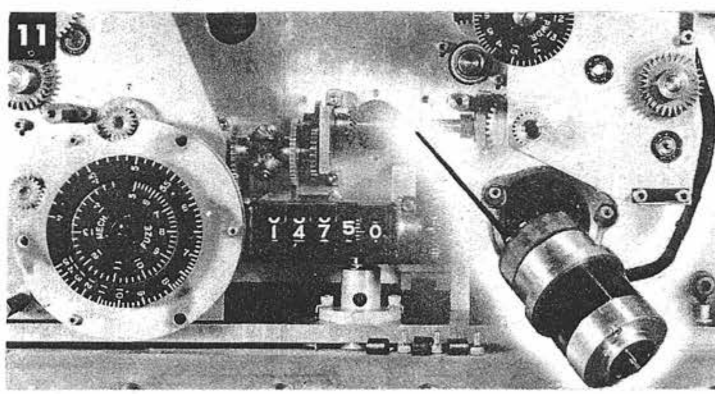
8 Remove the three screws securing the dial assembly.



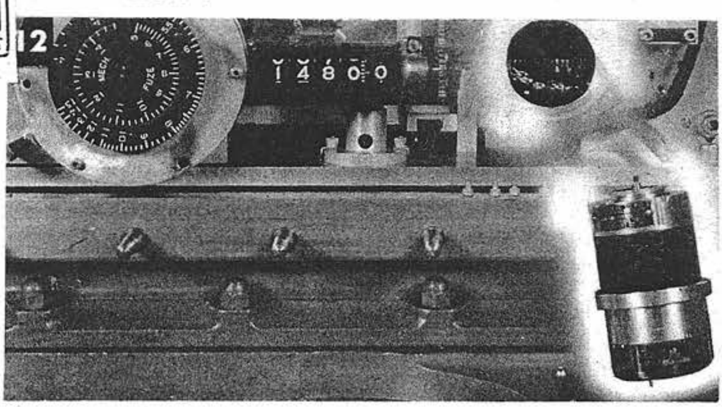
9 Remove dial assembly by working it back and forth.



10 Loosen, but do not remove, the three screws securing the *Rjn* motor to the frame.
Remove the three screws securing the *Rjn* motor cable clamps.



11 Partially remove the *Rjn* motor.

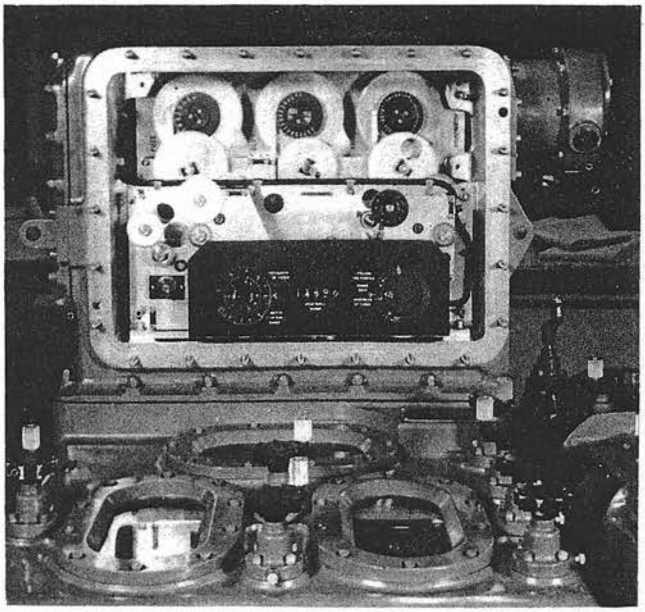


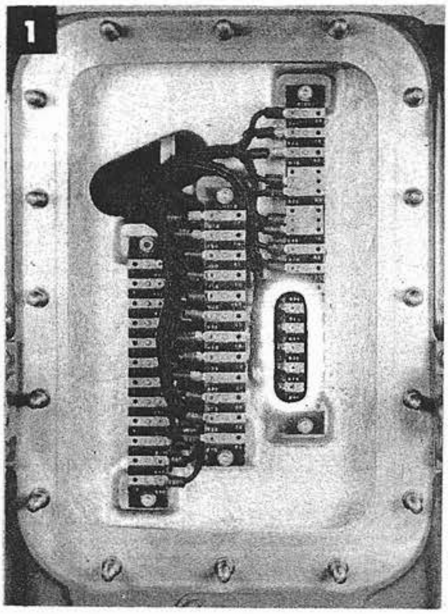
12 Remove the five screws connecting the cable leads to the base of the *Rjn* motor.
Remove the *Rjn* motor.

To reinstall the *Rjn* receiver motor, reverse the removal procedure.

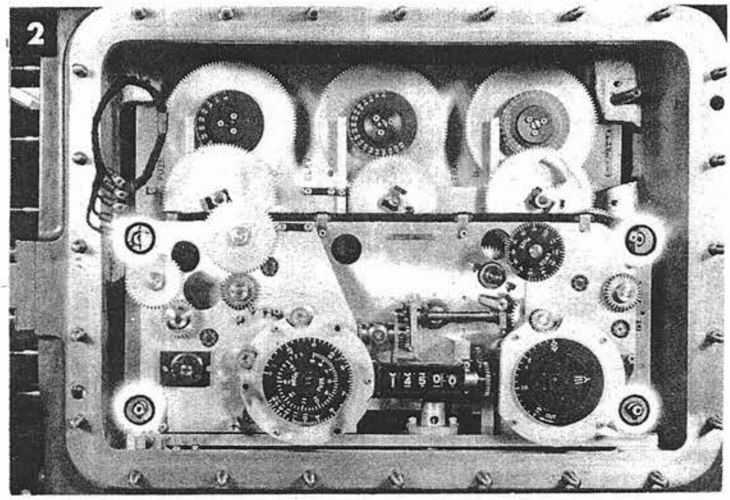
Readjust clamps A-56, A-2, A-3, A-4, A-10, and A-18.

MULTIPLIER GEARING

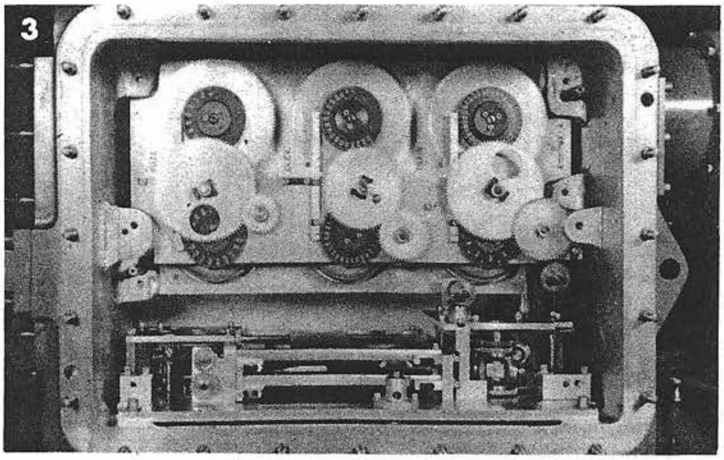




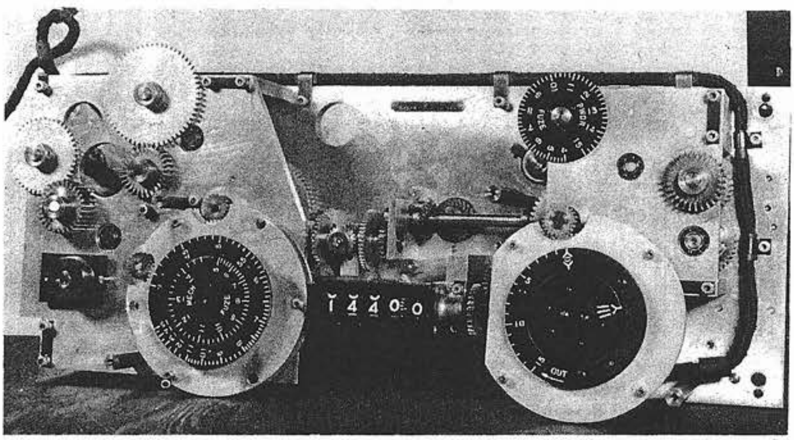
1 Remove the five screws connecting the *Rjn* motor cable leads to the terminal block in the junction box.



2 Remove the two screws securing the cable clamps to the wall of the computer. Ease the cable through the opening in the junction box. Remove the four screws securing the multiplier gearing.



3 Work the two dowels loose. Remove the multiplier gearing.

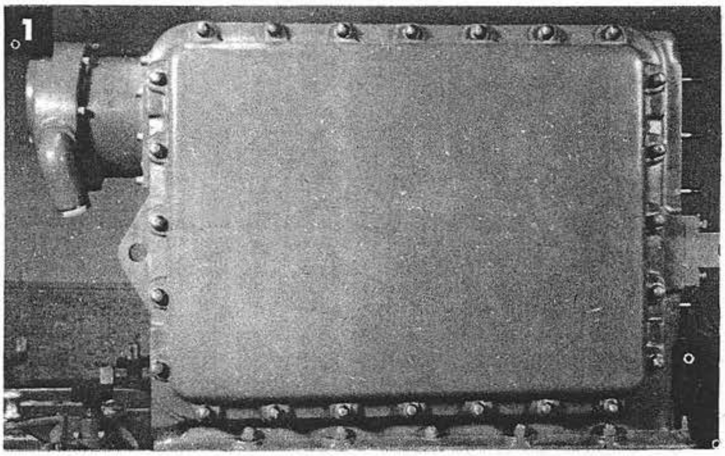


To reinstall the multiplier gearing, reverse the removal procedure.

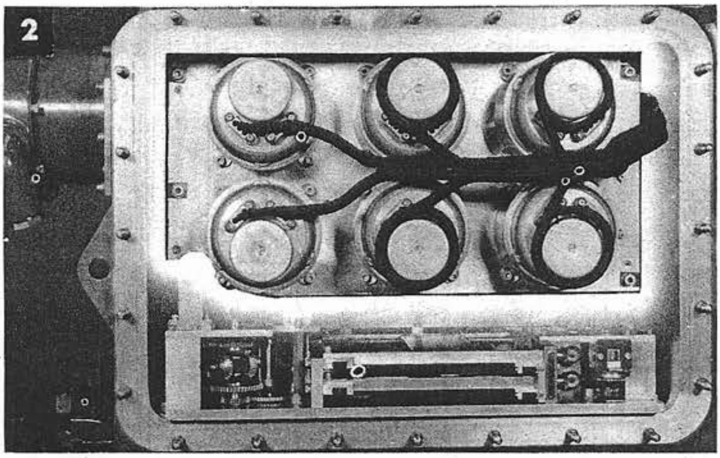
Readjust clamps A-16, A-57, A-10, A-9, and A-11.

Set the Star Shell Computer Mark 1 to Computer Mark 1 through clamps A-18, A-17, A-230, and A-231.

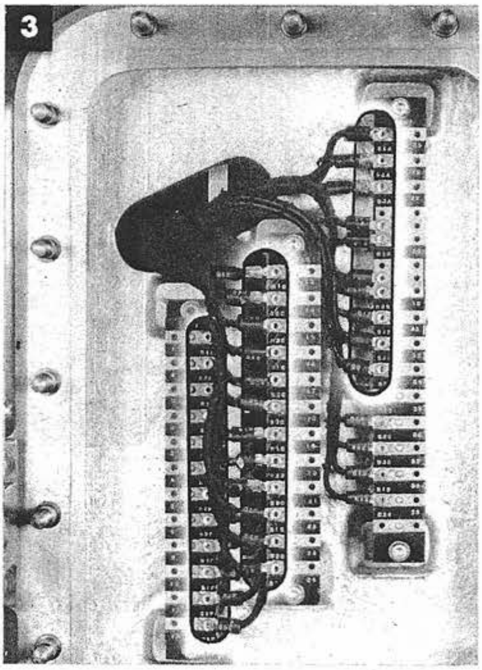
TRANSMITTER MOUNTING PLATE: FUZE, ELEVATION, AND TRAIN



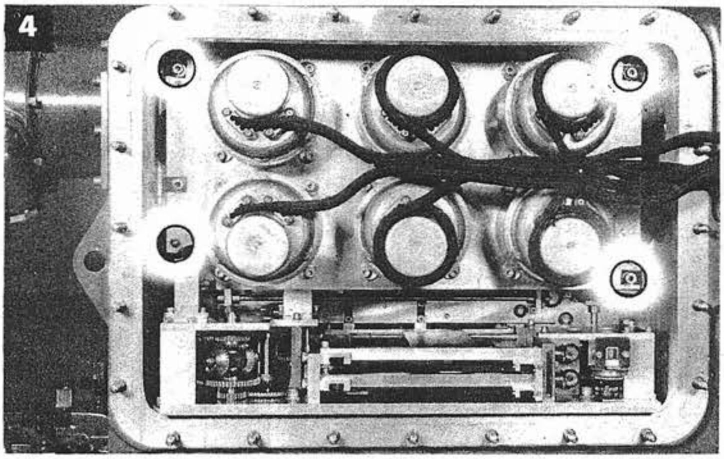
1 Remove the twenty-four acorn nuts securing the back cover.



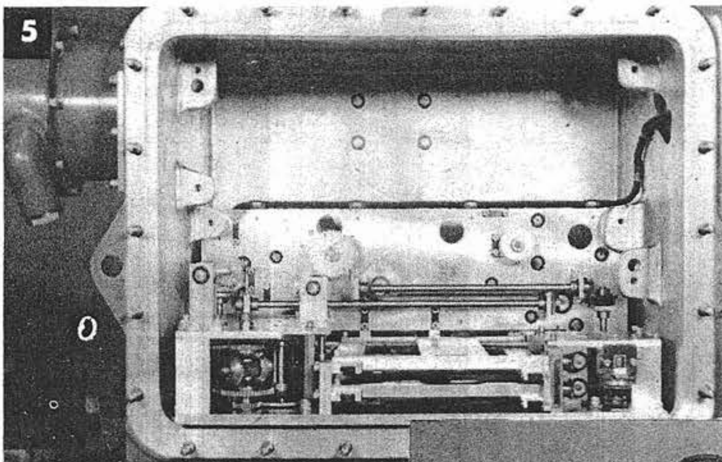
2 Remove the cover.



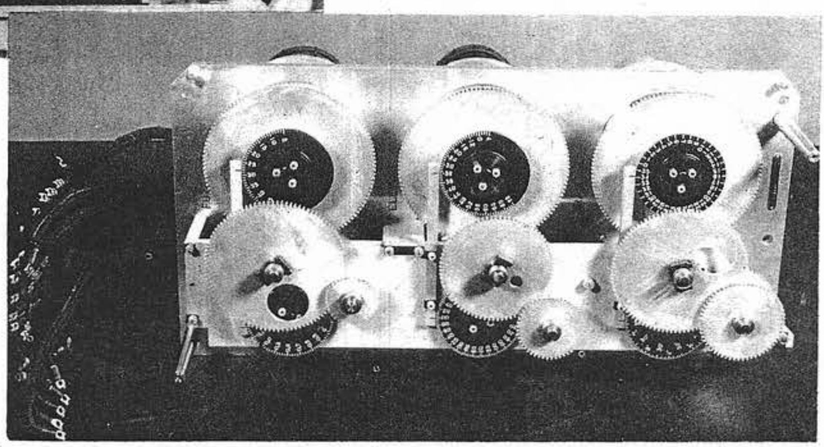
3 Remove the screws connecting the transmitter cable leads to the terminal blocks in the junction box. Ease the transmitter cables through the opening in the junction box.



4 Remove the four screws securing the transmitter mounting plate to the frame.



5 Remove the transmitter mounting plate.

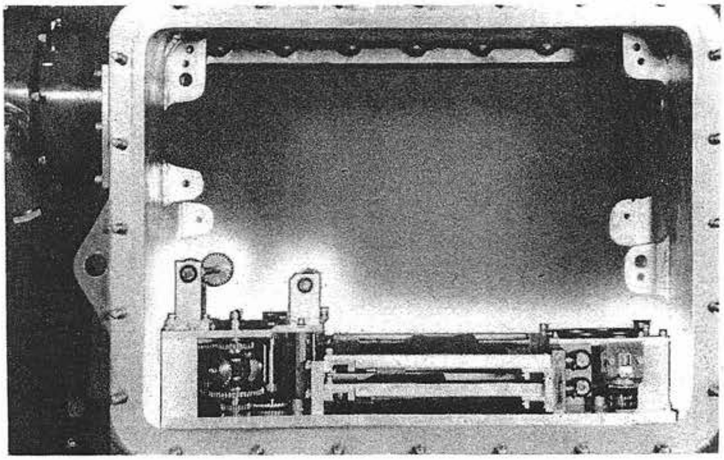


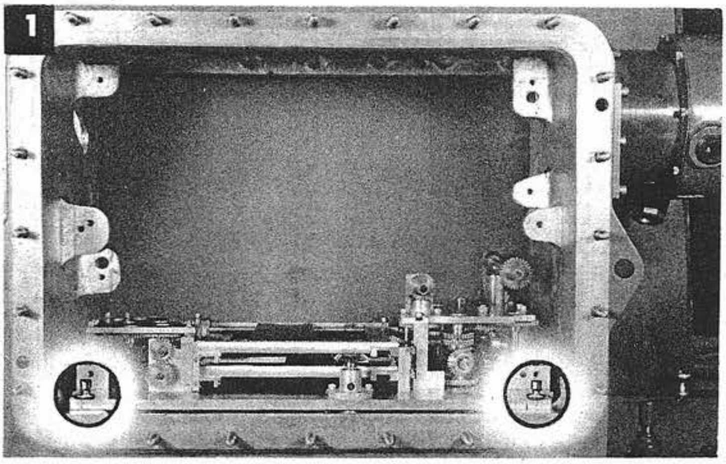
To reinstall the transmitter mounting plate, reverse the removal procedure.

Readjust clamps A-50, A-51, A-13, A-52, A-53, A-14, A-54, A-55, A-16, A-57, A-10, and A-9.

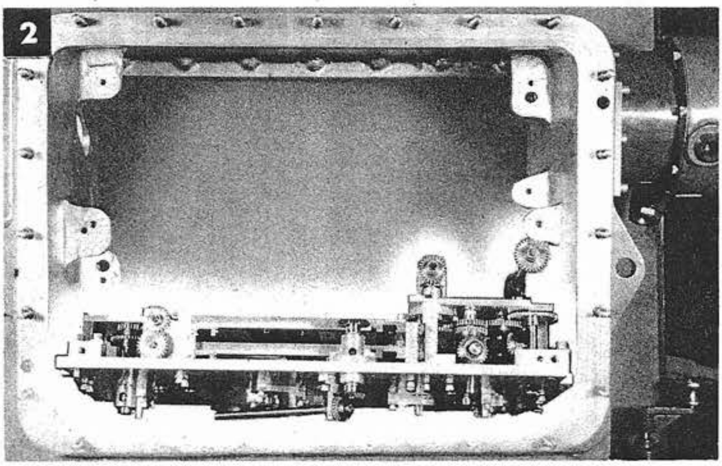
ELEVATION AND DEFLECTION MULTIPLIERS

Transmitter Mounting Plate, page 809
Multiplier Gearing, page 811

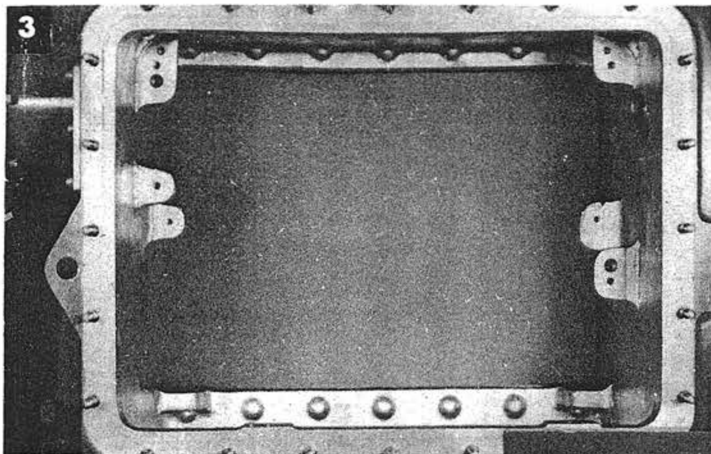




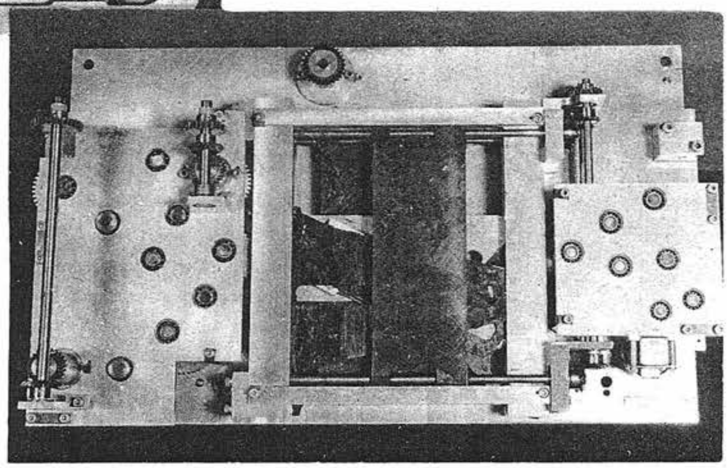
1 Remove the four screws securing the multiplier mounting plate.



2 Move the multiplier mounting plate to free the dowels. Tilt the plate to clear the gearing at the bottom.



3 Remove the multipliers.



To reinstall the elevation and deflection multipliers, reverse the removal procedure.

Readjust clamps A-50, A-51, A-13, A-52, A-53, A-14, A-54, A-55, A-15, A-56, A-2, A-3, A-4, A-6, A-16, A-5, A-7, A-8, A-1, A-57, A-10, A-9, A-12, and A-11.

Set the Star Shell Computer Mark 1 to Computer Mark 1 through clamps A-18, A-17, A-230, and A-231.

Part eight

FACTORY ADJUSTMENT PROCEDURE

Introduction

This section contains the basic reference data required for complete adjustment of the Computer Mark 1 and the Star Shell Computer Mark 1. This adjustment procedure should be followed whenever the entire instrument, or a major unit of the instrument, has been disassembled and reassembled. It is assumed that the maintenance personnel using this adjustment procedure will be experienced in the various operations and well acquainted with the instrument. If any further information on a particular adjustment is required, reference should be made to the *Readjustment Procedure*. For example, locations of the adjustment points have been omitted here. For the exact location of any adjustment, refer to the photos and locational description given in the *Readjustment Procedure*.

The sequence of adjustments has been carefully developed from methods used in the manufacturer's test department. The basic assumption is that all adjustment clamps are loose at the beginning. As the adjustment progresses, each step assumes that all previous adjustments have been properly made and permanently tightened. Therefore, if only part of the adjustment procedure is to be used, it is important to make sure that all previous adjustments are correct. The method of determining this depends upon the job, and the discretion of the maintenance man. In general, however, the checks given in the *Readjustment Procedure* may be used for this purpose.

In order to simplify presentation, and also to cover the majority of instruments, the procedure given here applies only to Computer Mk 1, Mods 7 and 13, Ser. Nos. 216 and higher, and to Star Shell Computer Mk 1, Mods 0 and 1.

When the instrument is to be completely adjusted, the star shell computer and all of the covers should be removed. To provide easier access to some adjustments, it is usually desirable to remove the *Co* and *Eb* receivers and both indicating and automatic *E'g* transmitters. They should be reinstalled when adjustments requiring their presence are reached in the adjustment sequence.

The electrical zero adjustment of the *Ds*, *Vs*, and *F* transmitters *must* be made with the units out of the instrument. This adjustment consists of positioning each synchro at electrical zero, then adjusting the synchro ring dial index mark to match the fixed index. The coarse and fine synchros of the double-speed transmitters may then be adjusted to each other. After reinstallation of these units, the index marks may be used for future reference to electrical zero.

In order to facilitate adjustment and test of the ballistic computers, it is desirable to remove all four units from the instrument. While each unit is on the bench, a 115-volt 60-cycle power supply may be connected temporarily to it, in order to energize the follow-up and run the test.

For making some of the adjustments, directions are given with respect to the front, rear, left, or right. In all of these cases, the directions refer to the corresponding side of the computer itself. They should not be confused with the apparent front, rear, left, or right of a unit as viewed through an access. The reference directions are explained and illustrated in the chapter on *Covers*.

Whenever an adjustment is made which involves energizing a follow-up, certain precautions should be taken before the leads are connected, in order to avoid damage to other units. First, the servo motor should be turned gently by hand to both limits of the protecting limit stop. Observe the limit stop itself to be certain that it is actually the stop that is hitting and not some more fragile element in an integrator, component solver, or multiplier. Secondly, in order to avoid runaway action, the follow-up should be synchronized at the desired point and the adjustment clamp made slip-tight before power is applied.

A follow-up may often be used to measure the accuracy of an adjustment before it has been finally synchronized in the normal sequence of adjustment. In such a case, it may be synchronized at a suitable position and energized temporarily. The precautions outlined above should be observed; and all inputs to the follow-up, except the one being measured, should be kept motionless.

Gene Slover's US Navy Pages

Table of Contents

GENERAL PLAN

The following procedure is for use when the computer is to be completely adjusted and brought into proper operating condition.

1 Refer to the list of assembly clamps, page 818, and tighten all of the assembly clamps in each unit, making sure that the parts are properly positioned.

2 Disconnect and tape the following power leads:

Designations	*Follow-up*	*Designations*	*Follow-up*
P, PP	*dRh*	F, FF	*Ywgr*
M, MM	*RdBs*	G, GG	*Dtwj*
E, EE	*dR*	H, HH	*V*
S, SS	*RdE*	J, JJ	*R2*
1G, 1GG	*WrD+KRdBs*	1B, 1BB	*Dd*
A, AA	*Tf*	1C, 1CC	*jB'r*
B, BB	*Tf/R2*	1D, 1DD	*Vz*
C1, CC	*Vf+Pe*	U, UU	*Co* receiver
D, DD	*F*	1A, 1AA	*Eb* receiver

Also, V and V1 on *Dj* knob switch
W and W1 on *Vj* knob switch
X and X1 on *Rj* handcrank switch
KRR1 on *Sh* handcrank switch

Make sure that all other leads are connected. (Reconnect each follow-up, or switch, as required to energize the associated circuit.)

3 Connect a 115-volt 60-cycle power supply to terminals PS and PPS.

4 Adjust and test each ballistic computer unit. If the units were adjusted on the bench, reinstall them in the computer.

5 Keep the following switches in the indicated position unless otherwise specified:
Power switch—ON
Time motor switch—OFF
Control switch—SEMI-AUTO
Range rate control switch—MANUAL

6 Make all adjustments in the control unit, the preliminary adjustments in the computer unit, and all adjustments in the indicator unit.

7 Replace control unit cover (No. 1) and indicator unit cover (No. 2). Make adjustments on all handcranks and knobs, as indicated.

8 Make all adjustments in computer unit, and in corrector unit up to A-513. If the *E'g* transmitters, *Eb* receiver, and *Co* receiver were removed, reinstall them and complete the adjustment of the instrument.

9 Adjust the star shell computer, mount it on cover 2, and adjust it to Computer Mark 1.

10 Run tests in the following order:
Test of operating limits
T/cR and (*T/cR*) sec *E* integrator check tests
Range B test
Elevation B test
Bearing B test
C test
A test
Star shell A test
Rate control test
Time motor regulator test
Transmission test

Gene Slover's US Navy Pages | Table of Contents

ASSEMBLY CLAMPS

The following counters must be adjusted to their drums at assembly. Use the clamp on the counter drum hub for this purpose.

E2 master counter (computer unit)
Tf master counter (computer unit)
Vf + *Pe* master counter (computer unit)
Tf/R2 master counter (computer unit)
T/cR counter (integrator group)
(*T/cR*) sec *E* counter (integrator group)
WrD + *KRdBs* counter (computer unit)
E counter (computer unit, Ser. Nos. 435 and higher)
E counter (corrector unit, Ser. Nos. 435 and higher)
E2 matching counter (corrector unit)
Vs master counter (corrector unit)
Ds master counter (corrector unit)

The following assembly clamps in each unit must be tightened before any adjustments are made.

Control Unit

A-166	Spur gear on roller of *jRc* integrator
A-167	Spur gear on roller of range integrator
A-168	Spur gear on output shaft of *jdR* motor
A-190	Spur gear driving fine *E* dial
A-207	Spur gear on *jBr* clutch
A-209	Dampers on *jBr, jE, jdR, dR, dRh, RdE, RdBs, Sh,* and *Ct* motors (9)
A-261	Shaft S1 in *Ct* follow-up
A-43	Single contact arm in *jBr, jE, dR, dRh, RdE, RdBs, Sh,* and *Ct* follow-ups (8)
A-232	Worm on 43-S41 to be out of mesh with *Ct* transmitter gear (Ser. Nos. 420 and lower, only)

Computer Unit

A-83	Spur gear driving *Vf* + *Pe* master counter
A-114	Shock absorbers on *dRs, E2,* and *cR* intermittent drives
A-182	Spur gear on input, *E2* intermittent drive

A-142, A-178 — Coupling on roller of $1/cR$ integrator

A-143, A-176 — Coupling on roller of sec E integrator

A-175 Spur gear on roller of elevation integrator

A-177 Spur gear on roller of bearing integrator

A-141 Spur gear driving T/cR counter. (On instruments with sliding gear, tighten out of mesh except when running tests.)

A-160 Spur gear driving T/cR sec E counter. (On instruments with sliding gear, tighten out of mesh except when running tests.)

A-146 Vernier adjustment of E to sec E cam (assembly clamp on Ser. Nos. 389 and lower, only)

A-211 Spur gear on 44-S6 (RdE)

A-218 Spur gear on 44-S1 (ΔcE)

A-219, A-225 — Spur gears on 44-S21 ($\Delta cB'r$)

A-238 Spur gear on magnetic drag in mesh with D-87 (bearing filter)

A-209 Damper on 44-A1 ($\Delta cB'r$)

A-209 Dampers on Co, $Dtwj$, $Ywgr$, V, $R2$, and $WrD + KRdBs$ motors (6)

A-230 Coupling between 45-A32 and 49-S34 (assembly clamp only if instrument is not equipped with star shell computer)

A-251 Shock absorber on E intermittent drive (Ser. Nos. 390 and higher, only)

A-43 Single contact arm on $Dtwj$, $Ywgr$, V, $R2$, and $WrD+KRdBs$ follow-ups, and Co receiver (6)

A-239 Spur gear on magnetic drag geared to fine synchro in Co receiver

Unnumbered Arms on input and output shafts of differential in Co receiver (2)

Indicator Unit

A-114 Shock absorbers on Ds and Vs intermittent drives

A-43 Single contact arm on Rj, Vj, Dj, and So receivers (4)

Gene Slover's US Navy Pages

Table of Contents

Corrector Unit

A-56 / A-59	Bevel gears on D-12 (*E*)
A-68	Bevel gear on *B′gr* auto transmitter
A-114	Shock absorber on output of (*Eb* + *Vs*) intermittent drive
A-209	Dampers on *B′r, Eb, Dd, jB′r,* and *Vz* motors (7)
A-231	Coupling between 14-B21 and 14-B25 (*E′g*) (assembly clamp only if instrument is not equipped with star shell computer)
A-53	Spur gear on output of *cB′r* motor
A-54	Spur gear on output of *B′r* motor
A-39	Spur gear on output of *Eb* motors (2)
A-43	Single contact arm on *Dd, jB′r, Vz,* and *cB′r* follow-ups and *B′r* and *Eb* receiver motors (6)
Unnumbered	Arms on input and output shafts of differentials in *B′r* and *Eb* receivers (4)
A-11	Output gear on *Dd, jB′r,* and *Vz* motors (3)

BALLISTIC COMPUTERS

Before adjusting a ballistic computer, adjust the counter drums to the counters. Use the adjustment clamp on the counter drum hub for this purpose. Check for clearance between the drum and the fixed index. Tighten the following assembly clamps in each ballistic computer:

A-209	Damper on servo motor
A-43	Single contact arm of follow-up control

To insert the 3/16-inch diameter setting rod, move the cam follower to the end of travel under the magnetic damper. Loosen A-209 temporarily and move the damper to the end of the motor shaft. Looking from the damper position toward the cam, two holes will be seen, a clearance hole in the frame and the setting hole in the follower. Rotate the cam to locate its corresponding setting hole.

The standard values given for counter readings while the setting rod is in place may be amended slightly in order to bring the test within the allowable limits. The amended values determined at the time of manufacture are recorded on the legend plate of the unit. They normally are the best initial values to use when readjusting. If a unit has been overhauled and repaired, however, the legend plate values may no longer be the most desirable ones. In such a case, the initial adjustment should be made with the given standard values.

Vf + Pe Ballistic Computer

Adj. No.	Quantity	Connection	Procedure
15	*E2*	*E2* counter to cam	Insert setting rod through follower and hole in cam. Set *E2* at 90° and *R2* at 17,000 yards. Remove setting rod and reposition motor damper.
17	*R2*	*R2* counter to cam	
16	*R2*	*R2* counter to L-23	Adjust so that stop acts at 300 and 18,200 yards on counter.
14	*Vf* + *Pe*	*Vf* + *Pe* counter to L-22	Adjust so that stop acts at 0 and 2500 min. on counter.
13	*Vf* + *Pe*	Cam output to *Vf* + *Pe* counter	Set R2 at 11,000 yards and *E2* at 0°. Synchronize *Vf* + *Pe* follow-up so that *Vf* + *Pe* = 746.8 min. on counter.

Make test of unit according to NIO acceptance test sheet. Improve readings as necessary by refining A-15 and A-17. When the readings are satisfactory, check the adjustment of L-23 and, if necessary, readjust A-16. Check that *E2* can be varied from 0 to 90°. Disconnect the follow-up power leads.

Tf/R2 Ballistic Computer

Adj. No.	Quantity	Connection	Procedure
40	*E2*	*E2* counter to cam	Insert setting rod through follower and hole in cam. Set *E2* at 90° and *R2* (or *R2m*) at 14,000 yards. Remove setting rod and reposition motor damper.
42	*R2* (or *R2m*)	*R2* (or *R2m*) counter to cam	
607	*jR2m* (*I.V.*)	*I.V.* dial to L-39	Adjust dial so that stop acts at 2350 and 2600 f.s. (On Ser. Nos. 811 and higher only.)
264	*jR2m* (*I.V.*)	Holding friction	Adjust holding friction so that other quantities will not back out *I.V.* line. (On Ser. Nos. 811 and higher only.)
41	*R2* (or *R2m*)	*R2* (or *R2m*) counter to L-21	Adjust so that stop acts at 300 and 18,200 yards on counter. (On Ser. Nos. 811 and higher, maintain *I.V.* at 2550 f.s.)
38	*Tf/R2*	*Tf/R2* counter to L-20	Adjust so that stop acts at 0.00122 and 0.00336 on counter.
37	*Tf/R2*	Cam output to *Tf/R2* counter	Set *R2* (or *R2m*) at 14,000 yards and *E2* at 0°. Synchronize *Tf/R2* follow-up so that *Tf/R2* = 0.002611 on counter.

 Table of Contents

Make test of unit according to NIO acceptance test sheet. Improve readings as necessary by refining A-40 and A-42. When the readings are satisfactory, check the adjustment of L-21 and, if necessary, readjust A-41. Check that *E2* can be varied from 0 to 90°. On Ser. Nos. 811 and higher, check that, with *R2* wedged, an increase of 50 f.s. *I.V.* causes a decrease of 225 yards *R2m*. Disconnect the follow-up power leads.

Tf Ballistic Computer

Adj. No.	Quantity	Connection	Procedure
20	*E2*	*E2* counter to cam	Insert setting rod through follower and hole in cam. Set *E2* at 90° and *R2* at 17,400 yards. Remove setting rod and reposition motor damper.
22	*R2*	*R2* counter to cam	
21	*R2*	*R2* counter to L-25	Adjust so that stop acts at 300 and 18,200 yards on counter.
19	*Tf*	*Tf* counter to L-24	Adjust so that stop acts at 0.6 and 60.6 sec. on counter.
18	*Tf*	Cam output to *Tf* counter	Set *R2* at 11,000 yards, and *E2* at 0°. Synchronize *Tf* follow-up so that *Tf* = 24.67 sec.

Make test of unit according to NIO acceptance test sheet. Improve readings as necessary by refining A-20 and A-22. When the readings are satisfactory, check the adjustment of L-25 and, if necessary, readjust A-21. Check that *E2* can be varied from 0 to 90°. Disconnect the follow-up power leads.

Mechanical Fuze Ballistic Computer (Ser. Nos. 780 and lower)

Adj. No.	Quantity	Connection	Procedure
46	*E2*	*E2* counter to cam	Insert setting rod through follower and hole in cam. Set *E2* at 90° and *R3* at 17,400 yards. Remove setting rod and reposition motor damper.
48	*R3*	*R3* counter to cam	
47	*R3*	*R3* counter to L-36	Adjust so that stop acts at –1250 yards (counter reading 98750) and +19,750 yards.
45	*F*	*F* counter to L-35	Adjust so that stop acts at 0.6 and 55 sec. on counter.
44	*F*	Cam output to *F* counter	Set *R3* at 11,000 yards and *E2* at 0°. Synchronize *F* follow-up so that *F* = 24.67 sec.

Make test of unit according to NIO acceptance test sheet. Improve readings as necessary by refining A-46 and A-48. When the readings are satisfactory, check the adjustment of L-36 and, if necessary, readjust A-47. Check that *E2* can be varied from 0 to 90°. Disconnect the follow-up power leads.

Mechanical Fuze Ballistic Computer (Ser. Nos. 781 and higher)

Adj. No.	Quantity	Connection	Procedure
45	*F*	*F* counter to L-35	Adjust counter so that stop acts at 0.6 and 55.0 sec.
46	*E2*	*E2* counter to cam	Insert setting rod through follower and hole in cam. Set *E2* at 90° and *F* at 54 sec. Remove setting rod and reposition motor damper.
47	*F*	*F* counter to cam	
48	*R3*	*R3* counter to L-36	Adjust counter so that stop acts at −13,150 yards (counter reading 86850) and +31,650 yards.
44	*F*	Cam output to *F* counter	Set *R3* at 10,000 yards, and *E2* at 0°. Synchronize *F* follow-up so that *F* = 21.22 sec.

Make test of unit according to NIO acceptance test sheet. Improve readings as necessary by refining A-46 and A-47. When the readings are satisfactory, check that *E2* can be varied from 0 to 90°. Disconnect the follow-up power leads.

CONTROL UNIT

Adj. No.	Quantity	Connection	Procedure
527	*So*	Dial to L-1	Adjust dial so that stop acts at 0 and 45 knots.
197	*Br*	Coarse to fine ring dial	Adjust ring dials to agree.
531	*Br*	Ship dial to *Br* dials	Adjust inner dial of ship dial group to agree with *Br* dials.
194	*Br*	Ship component solver to *Br* dials	Set *Br* at 0°. Position vector gear with slot toward rear. Movement of *So* cam should cause no movement of *Xo* rack. Motion of *Xo* rack may be measured on *RdBs* follow-up.

Adj. No.	Quantity	Connection	Procedure
127	*So*	Ship component solver to *So* dial	Set *So* at 0 knots. Position cam so that movement of vector gear through 360° causes no movement of output racks. Motion of *Xo* rack may be measured on *RdBs* follow-up.
193	*Sh*	Counter to L-2	Adjust counter so that stop acts at 0 and 400 knots.
532	*A*	Target component solver to *A* dial	Position vector gear with slot toward front. Adjust *A* dial to read 0°. Movement of *Sh* cam should cause no movement of *Xt* rack. Motion of *Xt* rack may be measured on *RdBs* follow-up.
192	*Sh*	Target component solver to *Sh* counter	Set *Sh* at 0 knots. Position cam so that movement of vector gear through 360° causes no movement of output racks. Motion of *Xt* rack may be measured on *RdBs* follow-up.
528	*Sw*	Dial to L-3	Adjust dial so that stop acts at 0 and 60 knots.
524	*Ss*	Dial to L-8	Adjust dial so that stop acts at ±450 knots. (One revolution of dial = 900 knots.)
202	*dH*	Friction drive	Adjust friction to slip when L-4 is against either limit.
525	*dH*	Dial to L-4	Adjust dial so that stop acts at +150 and −250 knots.
119	*dRh*	Ship and target component solvers to L-5	Set *So* at 40 knots, *Sh* at 400 knots, *Br* at 180°, and *A* at 180°. Position stop at upper limit (toward front) and synchronize *dRh* follow-up. Check that, with *A* at 0° and *Br* at 0°, stop is at lower limit.
189	*E*	Coarse to fine ring dial	Adjust ring dials to agree.
123	*E*	*dH* component solver to *E* dials	Set *E* at 0°. Position vector gear with gear end of lead screw toward front. Movement of *dH* lead screw should cause no movement of *dH* sin *E* rack. Motion of *dH* sin *E* rack may be measured on *dR* follow-up.
126	*dH*	*dH* component solver to *dH* dial	Set *dH* at 0 knots. Position lead screw so that movement of vector gear between limits of *E* causes no movement of output racks. Motion of *dH* sin *E* rack may be measured with a dial indicator.

Gene Slover's US Navy Pages | Table of Contents

Adj. No.	Quantity	Connection	Procedure
128	E	dRh component solver to E dials	Set E at 90°. Position vector gear with gear end of lead screw toward front. Movement of dRh lead screw should cause no movement of dRh cos E rack. Motion of dRh cos E rack may be measured on dR follow-up.
125	dRh	dRh component solver to dRh follow-up	Set So and Sh at 0 knots, and keep dRh follow-up energized. Position lead screw so that movement of vector gear between limits of E causes no movement of output racks. Motion of dRh cos E rack may be measured with a dial indicator.
163	dR	Component solvers to Ss dial	Set So, Sh, and dH at 0 knots, and keep dRh follow-up energized. Synchronize dR follow-up so that Ss dial reads 0.
170 171	dR	Range integrator to dR follow-up	Set So, Sh, and dH at 0 knots and keep dRh and dR follow-ups energized. Position integrator carriage in center of plate so that rotation of plate causes no movement of output roller.
118	RdE	Component solvers to L-7	Set So and dH at 0 knots, Sh at 400 knots, E at 90°, A at 0°, and keep dRh follow-up energized. Position stop at upper limit (toward rear) and synchronize RdE follow-up. Check that with A at 180°, stop is at lower limit.
121	$RdBs$	Component solvers to L-6	Set So at 0 knots, Sh at 400 knots, and A at 90°. Position stop at upper limit (toward left) and synchronize $RdBs$ follow-up. Check that, with A at 270°, stop is at lower limit.
204	jE	Holding friction	Adjust holding friction to prevent back drive of ΔcE, or jE motor.
529	cE	Fine cE dial to E dials	Set E at 0°. Turn control switch to AUTO. With jE motor synchronized, adjust one of the lines on fine cE dial to index. Split the dead space due to the widely spaced contacts.
201	jBr	Holding friction	Adjust holding friction to prevent back drive of ΔcBr, or jBr motor.
533	cBr	Fine cBr dial to Br dials	Set Br at 0°. Turn control switch to AUTO. With jBr motor synchronized, adjust one of the lines on fine cBr dial to index. Split the dead space due to the widely spaced contacts.

Adj. No.	Quantity	Connection	Procedure
136	A	Vector solver to A dial	*Adjust with power OFF.* Set A at 0° and wedge dial drive shaft 42-S93 at bevel gear end. Set true bearing (B) at 0°, and wedge. Use the A handcrank input gear to position the vector gear so that its rails are aligned fore and aft in instrument and so that the N-S rack can be pushed manually from its center position (position at which N-S input gear is in center of rack) to the *front* end of the rail. Refine so that moving N-S rack (and, therefore, speed pin carriage) between center and front causes no movement of E-W rack. Motion of E-W rack may be measured by depth gauge placed in E-W rail. Tighten A-136.
137	Sh	Vector solver to Sh counter	*Adjust with power OFF.* Set Sh at 0 knots, A at 90°, and true bearing (B) at 0°. Position E-W rack at zero point (depth gauge measurement established in adjusting A-136). Tighten A-137. Check that there is no motion of racks for rotation of Ct vector gear through 360°.
115	E	Elevation component integrators to E dials	Set E at 0°. Position jdR integrator angle gear so that jdR input shaft is vertical, with bevel gear at top. jdR input should cause no movement of jHc output, and increasing jEc should increase dH. Check that jEc input causes no motion of $jdRh$ output.
117	B	Bearing component integrators to B dial	Set B at 0°. Position jBc integrator angle gear so that jBc input shaft is horizontal, with bevel gear toward right. jBc input should cause no movement of N-S output, and increasing jBc should cause E-W friction drive gear to rotate clockwise as viewed from above. Check that $jdRh$ input causes no motion of E-W output.
222 223	jEc jBc	Holding frictions	Adjust holding frictions to maintain settings of jEc and jBc.
130	jHc	Friction drive	Adjust friction drive to slip when dH is introduced with handcrank.

Table of Contents

Gene Slover's US Navy Pages

Adj. No.	Quantity	Connection	Procedure
205	N-S change	Friction drive	Adjust friction drive to slip when *Ct* or *Sh* is introduced by handcrank. Usual adjustment is 3½ turns from point where clamp just touches washer.
206	E-W change	Friction drive	Adjust friction drive to slip when *Ct* or *Sh* is introduced by handcrank. Usual adjustment is 3½ turns from point where clamp just touches washer.
191	Time	Friction drive	Adjust friction drive to slip when time crank is turned in its IN position.
161	Time	Friction drive	Adjust friction drive to slip when regulator input gear is turned backwards.
172 173	*Rrr*	Range correction integrator to L-13	Remove block from stop arm. With stop against lower limit, position integrator carriage in center of plate so that rotation of plate causes no movement of output roller. Replace block on stop arm.
187	*jR*	Holding friction	Adjust friction to hold *jR* setting for both positions of *jR* handcrank.
546	*cR*	Coarse ring dial to coarse follow-up control on range receiver	Remove fine synchro dial. Turn range rate control switch to AUTO. Position range correction integrator carriage at maximum radius. Put power on *jdR* motor by energizing range finder signal circuit. Put index on coarse synchro dial near Y index on coarse ring dial in order to locate position where *jdR* motor does not drive. Rotate synchro dial slightly in opposite direction and note positions, measured against ring dial, where *jdR* motor starts to drive. Adjust ring dial so that these two positions lie equal distances on opposite sides of the Y index on ring dial.
545	*cR*	Fine ring dial to fine follow-up control on range receiver	Replace fine synchro dial. Tighten A-196 enough to drive fine ring dial, making sure that L-10 is not hitting either limit. Manually hold index of coarse synchro dial opposite index of coarse ring dial (this will energize fine follow-up). Fine follow-up will then drive to synchronism. Adjust fine ring dial so that its index matches the index on the fine synchro dial.

Adj. No.	Quantity	Connection	Procedure
195	*cR*	Coarse to fine ring dial	Adjust ring dials to agree. (Y index on fine ring dial indicates *even* thousands of yards.)
196	*cR*	Dials to L-10	Adjust so that stop acts at 0 and 35,000 yards.
520	*R*	Dial to coarse synchro motor	Turn power OFF. Set *cR* ring dials at 10,000 yards. Put coarse range synchro on electrical zero. Adjust pointer of synchro dial to match index on ring dial.
521	*R*	Dial to fine synchro motor	Put fine range synchro on electrical zero. Adjust pointer of synchro dial to match fixed index.
240 164	*jdR* *jdR*	Holding frictions	Adjust frictions to obtain smooth operation of range receiver and synchronizing time within prescribed limits. A-240 should prevent *E* or *jEc* from backing out *jdR* line with *jdR* clutch open. A-164 should prevent *jR* or Δ*cR* from backing out through range correction integrator.
124	*E*	Height computer to *E* dials	Set *E* at 0°. Position vector gear with slot to front. Movement of *cR* cam should cause no movement of output rack. Motion of rack may be observed on *H* dials.
158	*H*	Spring to height dial drive	Set *E* at –25°. Position *cR* cam follower at end of slot on outer radius. Wind spring fully. Recheck A-124.
522	*H*	Coarse *H* dial to *H* computer	Set *E* at 0°. Adjust coarse *H* dial to 0.
523	*H*	Fine *H* dial to *H* computer	Set *E* at 0°. Adjust fine *H* dial to 0.
138	*cR*	Height computer to *cR* dials	Set *E* at 90° and *cR* at 8,000 yards. Position *cR* cam so that *H* dials read 24,000 feet.
116	*E*	*E* dials to L-12	Adjust so that stop acts at –25° and +85° on *E* dials (Ser. Nos. 390 and higher) or –5° and +85° (Ser. Nos. 389 and lower).
122	*So*	Holding friction	Adjust holding friction so that changing *Br* will not disturb *So* setting. Friction must not be so tight as to overload *So* receiver servo motor.

Adj. No.	Quantity	Connection	Procedure
200	*Bw*	Holding friction	Adjust holding friction so that changing *B* will not disturb *Bw* setting.
258	*Ct*	Transmitter to dials	Set *A* at 0° and *B* at 180°. Position *Ct* transmitter on electrical zero.

PRELIMINARY ADJUSTMENTS IN COMPUTER UNIT

Adj. No.	Quantity	Connection	Procedure
536	*I.V.*	*I.V.* dial to L-15	Adjust dial so that stop acts at 2350 and 2600 f.s.
120	*Vfm*	Holding friction	Adjust holding friction so that other quantities will not back out *I.V.* line.
82	*Vf + Pe*	Master counter to ballistic computer	Adjust so that *Vf + Pe* master counter agrees with *Vf + Pe* counter in ballistic computer.
198	*Ds*	Counter to L-28	Set *Vf + Pe* at 100 min. and *I.V.* at 2550 f.s. Adjust so that *Dtwj* stop acts at 1018 (+518) and 9982 (–518) mils on *Ds* master counter in corrector unit.
184	*Vs*	Counter to L-37	Set *Vf + Pe* at 0 min. and *I.V.* at 2550 f.s. Adjust so that *V* stop acts at 200 and 3800 min. on *Vs* master counter in corrector unit.

INDICATOR UNIT

Adj. No.	Quantity	Connection	Procedure
500	*Dj*	Dial to L-30	Adjust dial so that stop acts at RIGHT 180 and LEFT 180 mils.
501	*Vj*	Dial to L-31	Adjust dial so that stop acts at UP 180 and DOWN 180 mils.
234 235	*Rj*	Counters to L-29	Adjust counters so that stop acts at IN 12,000 and OUT 1800 yards.
185 186 174	*Dj* *Vj* *Rj*	Holding frictions	Adjust holding frictions so that other quantities will not back out lines on which they are located. Frictions should not overload receiver servo motors.

Adj. No.	Quantity	Connection	Procedure
86 87	*Dj* *Vj*	Dial to receiver Dial to receiver	Hold receivers on electrical zero, with follow-ups energized. Adjust so that corresponding dials read zero.
88	*Rj*	Counters to receiver	Hold receiver on electrical zero, with follow-up energized. Adjust so that *Rj* counters read zero.
212	*So*	Dial to receiver	Hold receiver on electrical zero, with follow-up energized. Adjust so that *So* dial reads zero.
213	*Ds*	Coarse to fine synchro (double-speed transmitter)	Hold fine *Ds* synchro on electrical zero. Adjust so that coarse *Ds* synchro is on electrical zero.
94	*Ds*	Counter to double-speed transmitter	Hold *Ds* double-speed transmitter on electrical zero. Adjust *Ds* indicating counter to read 500 mils.
89	*Ds*	Indicating counter to master counter	Adjust so that *Ds* indicating counter agrees with *Ds* master counter in corrector unit.
96	*Ds*	Intermittent drive to counter	Adjust so that intermittent drive cuts out at 320 and 680 mils on *Ds* counter.
66	*Ds*	Single-speed transmitter to counter	Set *Ds* at 500 mils. Adjust so that *Ds* single-speed transmitter is on electrical zero.
214	*Vs*	Coarse to fine synchro (double-speed transmitter)	Hold fine *Vs* synchro on electrical zero. Adjust so that coarse *Vs* synchro is on electrical zero.
95	*Vs*	Counter to double-speed transmitter	Hold *Vs* double-speed transmitter on electrical zero. Adjust *Vs* indicating counter to read 2000 min.
55	*Vs*	Indicating counter to master counter	Adjust so that *Vs* indicating counter agrees with *Vs* master counter in corrector unit.
97	*Vs*	Intermittent drive to counter	Adjust so that intermittent drive cuts out at 2000 and 3800 min. on *Vs* counter.
69	*Vs*	Single-speed transmitter to counter	Set *Vs* at 2000 min. Adjust so that *Vs* single-speed transmitter is on electrical zero.
67	*F*	Coarse to fine synchro (*F* transmitter)	Hold fine *F* synchro on electrical zero. Adjust so that coarse *F* synchro is on electrical zero.

 Table of Contents

Adj. No.	Quantity	Connection	Procedure
93	*F*	Counter to transmitter	Hold *F* transmitter on electrical zero. Adjust *F* indicating counter to read 10.00 sec.
77	*F*	Indicating counter to ballistic computer	Adjust so that *F* indicating counter agrees with *F* counter in ballistic computer.

HANDCRANKS

The following table indicates which handcranks have friction relief drives and holding frictions, and which ones operate switches.

Adjust each friction relief drive so as to drive the line normally without slipping when the handcrank is turned, but to slip without straining the line when the limit is reached.

Adjust each holding friction so that the quantity will not back out in normal operation.

Adjust each switch-actuating screw so that when the handcrank is put in the IN position, the switch will open before the gears mesh. Make sure that the screw does not extend so far as to damage the switch when the handcrank is put in the IN position. Check that the switch is closed when the handcrank is in the OUT position.

Handcrank	Friction drive	Holding friction	Operates switch
Deflection Spot (*Dj*)	X	X	X
Elevation Spot (*Vj*)	X	X	X
Range Spot (*Rj*)	X	X	X
Fuze (*F*)	X	X	X
Sight Angle (*Vs*)	X	X	X
Sight Deflection (*Ds*)	X	X	X
Synchronize Elevation (sync *E*)	X	Note A	Note B
Wind Speed (*Sw*)	X		
Ship Speed (*So*)	X	X	X

Continued on Page 832

NOTE A: Holding friction to be such that handcrank in IN position rotates when either limit of L-12 is reached.
NOTE B: Switch to be open in OUT position, and closed in CENTER and IN positions.

Continued from Page 831

Handcrank	Friction drive	Holding friction	Operates switch
Target Speed (*Sh*)	X	X	X
Rate of Climb (*dH*)		Fixed	
Target Angle (*A*)		X	X
Ship Course (*Co*)		X	X
Wind Direction (*Bw*)		No Adjustments	
Range Rate (*dR*)	X	X	X
Time (*T*)	X		
Generated Range (*jR*)	X		
Generated Bearing (*jBr*)		No Adjustments	
Generated Elevation (*jE*)	X		
Range Rate Ratio (*Rrr*)		X	
Dead Time (*Tg*)	X		
Initial Velocity (*I.V.*) (both front and left knobs on Ser. Nos. 811 and higher)	X		

COMPUTER UNIT

Adj. No.	Quantity	Connection	Procedure
233	*cR*	Intermittent drive to dials	Adjust so that intermittent drive cuts out at 750 and 22,500 yards on *cR* dials.
151 152	*cR*	1/*cR* cam to *cR* dials	Set *cR* at 1500 yards. Turn 1/*cR* cam so that 1/*cR* integrator carriage moves upward. Position cam at beginning of outer constant radius, where further rotation of cam causes no further upward movement of integrator carriage.
149	1/*cR*	1/*cR* integrator to 1/*cR* cam	Set *cR* at 2790 yards. Position integrator carriage in center of plate so that rotation of plate causes no movement of output roller.
260	*E*	*E* counter in computer unit to *E* dials	Adjust so that *E* counter agrees with *E* dials. (In Ser. Nos 435 and higher only.)
250	*E*	Intermittent drive to dials	Adjust so that intermittent drive cuts out at $-2°$ and $+85°$ on *E* dials. (In Ser. Nos. 390 and higher only.)

Adj. No.	Quantity	Connection	Procedure
210 145	*E*	Sec *E* cam to *E* dials (Ser. Nos. 389 and lower)	Set *E* at $71^\circ 12'$. Turn sec *E* cam so that sec *E* integrator carriage moves upward. Position cam at beginning of outer constant radius, where further rotation of cam causes no further upward movement of integrator carriage.
145 146	*E*	Sec *E* cam to *E* dials (Ser. Nos. 390 and higher)	
147	Sec *E*	Sec *E* integrator to sec *E* cam	Set *E* at $60^\circ 49'$. Position integrator carriage in center of plate so that rotation of plate causes no movement of output roller.
108	*RdE*	Range rate corrector to *RdE* follow-up	Set *So*, *Sh*, and *dH* at 0 knots, and *E* at 0°. Keep *RdE* and *RdBs* follow-ups energized. Turn range rate corrector cams until 1/16-inch diameter setting rod can be inserted through both cams, both follower rollers, and the mounting plate. The rod should go in approximately 2 inches. Tighten A-108 and A-109 and REMOVE SETTING ROD.
109	*RdBs*	Range rate corrector to *RdBs* follow-up	
154 155	*RdE*	Elevation integrator to *RdE* follow-up	Set *dH* at 0 knots, and *E* at 0°. Keep *RdE* follow-up energized. Position integrator carriage in center of plate so that rotation of plate causes no movement of output roller.
139 140	*RdBs*	Bearing integrator to *RdBs* follow-up	Set *So* and *Sh* at 0 knots, and *Br* and *A* at 0°. Keep *RdBs* follow-up energized. Position integrator carriage in center of plate so that rotation of plate causes no movement of output roller.
105	*Bws*	Horizontal wind component solver to *Bws* dial	Set *Bws* at 0° and *Ds* at 500 mils. Position vector gear with slot toward left. Movement of *Sw* cam should cause no movement of *Xwg* rack.
157	*Sw*	Horizontal wind component solver to *Sw* dial	Set *Sw* at 0 knots. Position cam so that movement of vector gear through 360° causes no movement of output racks.
129	*Sw*	Holding friction	Adjust friction so that changing *Bwg* will not disturb *Sw* setting.

Adj. No.	Quantity	Connection	Procedure
181	dRs	dRs intermittent drive to Ss dial	Set So, Sh, and dH at 0 knots, E at 0°, and $I.V.$ at 2550 f.s. Keep $RdBs$ and RdE follow-ups energized. Adjust so that intermittent drive cuts out at +450 knots and −450 knots on Ss dial. To check the adjustment, set Ss at −450 knots, increase $I.V.$ through 2550, and observe cut-out point on $I.V.$ dial. Cut-out should occur as $I.V.$ passes through 2550. Set Ss at +450 knots and check the opposite cut-out point by decreasing $I.V.$ through 2550. Balance the errors in the $I.V.$ dial readings. Cut-out point may be observed on dRs shaft 45-A25 located just below $I.V.$ dial.
101	$Ywgr$	Component solvers to L-9	Set So at 40 knots, Sw at 60 knots, Ds at 500 mils, Br and Bws at 0°. Position stop at upper limit (toward rear) and synchronize $Ywgr$ follow-up. Check that, with Br and Bws at 180°, stop is at lower limit.
72	$E2$	$E2$ counter to intermittent drive	Adjust counter so that intermittent drive cuts out at 0° and 90°.
106	$E2$	Elevation wind component solver to $E2$ counter	Set $E2$ at 78.95°. Position vector gear with lead screw horizontal and gear end toward right. Movement of lead screw should cause no movement of WrR rack.
100	$Ywgr$	Elevation wind component solver to $Ywgr$ follow-up	Set So and Sw at 0 knots, Br and Bws at 90° and Ds at 500 mils. Keep $Ywgr$ follow-up energized. Position lead screw so that movement of vector gear between limits of $E2$ causes no movement of output racks.
79	$Tf/R2$	Elevation prediction multiplier to $Tf/R2$ master counter	Set $Tf/R2$ at 0.00115. Position input screw so that movement of input rack causes no movement of output rack. Motion of output rack may be measured on V follow-up. (For approximate adjustment, position nut at lower limit and set $Tf/R2$ at 0.001094.)

Adj. No.	Quantity	Connection	Procedure
134	*WrE*	Elevation prediction multiplier to component solvers	Set *So, Sh, Sw*, and *dH* at 0 knots, and *E* and *E2* at 0°. Keep *dRh, RdE*, and *Ywgr* follow-ups energized. Position input rack so that rotation of input screw causes no movement of output rack. Motion of output rack may be measured on *V* follow-up.
81	*Tf*	Range prediction multiplier to *Tf* master counter	Set *Tf* at 5.00 seconds. Position input screw so that movement of input rack causes no movement of output rack. Motion of output rack may be measured on *R2* follow-up. (For approximate adjustment, position nut at lower limit and set *Tf* at –0.95 sec.) (99.05 on counter.)
135	*dRs*	Range prediction multiplier to component solvers	Set *So, Sh, Sw*, and *dH* at 0 knots, *E* at 0°, *I.V.* at 2550 f.s. Keep *dRh, dR, RdE, RdBs*, and *Ywgr* follow-ups energized. Position input rack so that rotation of input screw causes no movement of output rack. Motion of output rack may be measured on *R2* follow-up.
535 (Ser. Nos. 780 and lower)	*Tg*	Dial to L-14	Adjust dial so that stop acts at 0 and 6 sec.
535 (Ser. Nos. 781 and higher)	*Tg*	Dial to L-38	Adjust dial so that stop acts at 0 and 6 sec.
262 (Ser. Nos. 781 and higher)	$Tg+F-Tf$	$Tg+F-Tf$ to L-14	Set *Tg* at 0 sec.and *F* at 51 sec. Adjust so that stop acts at 1 and 51 sec. on *Tf* counter.
263 (Ser. Nos. 781 and higher)	*Tg*	Holding friction	Adjust holding friction so that *F* and Tf cannot back out *Tg* line when at either end of L-14.
188 (Ser. Nos. 780 and lower)	*Tg*	Dead time prediction multiplier to *Tg* dial	Set *Tg* at 0 seconds. Position input screw so that movement of input rack causes no movement of output rack. Motion of output rack may be measured on *R3* counter. (For approximate adjustment, position screw 1.5 turns from lower limit of nut travel.)

Adj. No.	Quantity	Connection	Procedure
188 (Ser. Nos. 781 and higher)	$Tg+F-Tf$	Dead time prediction multiplier to $Tg+F-Tf$	Set Tg at 0 seconds, F and Tf at 10 seconds. Position input screw so that movement of input rack causes no movement of output rack. Motion of output rack may be measured on *R3* counter. (For approximate adjustment, position screw 1.5 turns from lower limit of nut travel.)
132 (Ser. Nos. 780 and lower)	dR	Dead time prediction multiplier to dR follow-up	Set *So*, *Sh*, and dH at 0 knots. Keep dRh and dR follow-ups energized. Position input rack so that rotation of input screw causes no movement of output rack. Motion of output rack may be measured on *R3* counter.
132 (Ser. Nos. 781 and higher)	$dRs-dRm$	Dead time prediction multiplier to $dRs-dRm$	Set *So*, *Sh*, and dH at 0 knots and *I.V.* at 2550 f.s. Keep dRh, dR, RdE, and $RdBs$ follow-ups energized. Position input rack so that rotation of input screw causes no movement of output rack. Motion of output rack may be measured on *R3* counter.
71	*E2*	Counter in $Tf/R2$ unit to *E2* master counter	Adjust so that *E2* counter in each ballistic computer unit agrees with *E2* master counter.
73	*E2*	Counter in *F* unit to *E2* master counter	
84	*E2*	Counter in *Tf* unit to *E2* master counter	
85	*E2*	Counter in $Vf+Pe$ unit to *E2* master counter	
183	*E2*	Counter in corrector unit to *E2* master counter	Adjust so that *E2* counters agree.
80	*Tf*	Counter in *Tf* unit to *Tf* master counter	Adjust so that *Tf* counters agree.
74	*R2*	*R2* counter in *Tf* unit to L-19	Adjust so that stop acts at 500 and 18,000 yards on counter.

Adj. No.	Quantity	Connection	Procedure
75	$R2$	Counter in $Vf + Pe$ unit to counter in Tf unit	Adjust so that $R2$ counters agree.
76	$R2$	Counter in $Tf/R2$ unit to counter in Tf unit	In Ser. Nos. 810 and lower, adjust so that $R2$ counters agree. In Ser. Nos. 811 and higher, set front $I.V.$ at 2550 f.s. and adjust so that $R2m$ counter agrees with $R2$ counter.
203	$R3$	$R3$ counter to dead time prediction multiplier and $R2$ counters	Set Tg at 0 seconds. In instruments with Ser. Nos. 781 and higher, also set F equal to Tf. Adjust so that $R3$ counter in F ballistic computer agrees with $R2$ counters. Reconnect F motor.
104	$R2$	$R2$ counters to multiplier output gearing	Set So, Sh, Sw, and dH at 0 knots, Tf at 5.00 sec., Rj at 0 yards, $I.V.$ at 2550 f.s. and cR at 2000 yards. Keep dRh, dR, RdE, $RdBs$, and $Ywgr$ follow-ups energized. Wind take-up spring 3 turns. Synchronize $R2$ follow-up so that $R2$ counters read 2000 yards. Reconnect Tf motor.
220		Spring to line	
180	E	$E2$ counters to E dials	Set E at 1°, $Vf + Pe$ at 0 min., Vs at 2000 min., and $I.V.$ at 2550 f.s. Adjust so that $E2$ counters read 1°.
110	Ds	Complementary error corrector to Ds counter	Set Ds at 500 mils. Position $(Ds)^2$ cam so that follower is fully toward right. Tighten A-110. To refine: Set So, Sh, Sw, and dH at 0 knots, and $Vf + Pe$ at 0 min. Keep dRh, RdE and $Ywgr$ follow-ups energized. Synchronize V follow-up temporarily with A-103, so that Vs is approximately equal to 2000 min. Position $f(E2)$ cam so that follower is nearest center. Adjust $(Ds)^2$ cam so that Vs decreases to the same reading when Ds is moved to 100 or 900 mils.
103	V	Vs counter to multiplier output gearing	Set So, Sh, Sw, and dH at 0 knots, Vj at 0 mils, Ds at 500 mils, $Vf + Pe$ at 0 min., $I.V.$ at 2550 f.s., and $Tf/R2$ at 0.001150. Keep dRh, RdE, and $Ywgr$ follow-ups energized. Wind take-up spring 3 turns. Synchronize V follow-up so that Vs counter reads 2000 min.
221		Spring to line	

Adj. No.	Quantity	Connection	Procedure
107	$E2$	Complementary error corrector to $E2$ counter	Set *So, Sh, Sw,* and *dH* at 0 knots, *Vj* at 0 mils, *Ds* at 500 mils, and $E2$ at 65°. Keep *dRh, RdE, Ywgr,* and *V* follow-ups energized. Read *E* dials. Set *Ds* at 100 mils and turn *E* with sync *E* handcrank at CENTER until *E* dials read 11°07′ higher than before. Position $f(E2)$ cam so that $E2$ reads 65°.
133	$Tf/R2$	Deflection prediction multiplier to $Tf/R2$ master counter	Set $Tf/R2$ at 0.00125. Position input screw so that movement of input rack causes no movement of output rack. Motion of output rack may be measured on *Dtwj* follow-up. (For approximate adjustment, position nut at lower limit and set $Tf/R2$ at 0.001196.)
131	*RdBs*	Deflection prediction multiplier to component solvers	Set *So, Sh,* and *Sw* at 0 knots. Keep *RdBs* follow-up energized. Position input rack so that rotation of input screw causes no movement of output rack. Motion of output rack may be measured on *Dtwj* follow-up.
102	*Dtwj*	*Ds* counter to multiplier output gearing	Set *So, Sh,* and *Sw* at 0 knots, *Dj* at 0 mils, *I.V.* at 2550 f.s., $Tf/R2$ at 0.00125 and $Vf+Pe$ at 100 min. Keep *RdBs* follow-up energized. Wind take-up spring 3 turns. Synchronize *Dtwj* follow-up so that *Ds* counter reads 500 mils. Reconnect $Vf+Pe$ motor.
217		Spring to line	
78	$Tf/R2$	Counter in $Tf/R2$ unit to $Tf/R2$ master counter	Adjust so that $Tf/R2$ counters agree. Reconnect $Tf/R2$ motor.
229	$WrD+KRdBs$	Counter to component solvers	Set *So, Sh,* and *Sw* at 0 knots. Keep *RdBs* follow-up energized. Adjust S.S. deflection counter to read zero.
153	$L+Zd/30$	Locking gear to $L+Zd/30$	Position locking gear out of mesh with gear on 44-S55 and tighten clamp.

CORRECTOR UNIT

Adj. No.	Quantity	Connection	Procedure
507	*Zd*	Coarse to fine dial	Adjust dials to agree.
30	*Zd*	Dials to L-17	Adjust so that stop acts at 480 and 3520 min. on *Zd* dials.
505	*L*	Coarse to fine dial	Adjust dials to agree.
506	*Vz*	Coarse to fine dial	Adjust dials to agree.
29	*Vz*	Dials to L-34	Adjust so that stop acts at +1860 and −2940 min. on *Vz* dials.
508	*Dd*	Coarse to fine dial	Adjust dials to agree.
31	*Dd*	Dials to L-32	Adjust so that stop acts at ±120° on *Dd* dials.
509	*B′gr*	Dial to coarse synchro (automatic transmitter)	Hold synchros on electrical zero. Adjust dials to read zero.
510	*B′gr*	Dial to fine synchro (automatic transmitter)	
7	*B′gr*	Coarse to fine synchro (automatic transmitter)	Adjust so that coarse and fine synchros are on electrical zero together (dials to agree).
511	*B′gr*	Dial to coarse synchro (indicating transmitter)	Hold synchros on electrical zero. Adjust dials to read zero.
512	*B′gr*	Dial to fine synchro (indicating transmitter)	
9	*B′gr*	Coarse to fine synchro (indicating transmitter)	Adjust so that coarse and fine synchros are on electrical zero together (dials to agree).
8	*B′gr*	Indicating to automatic transmitter	Adjust so that transmitter dials agree.

Adj. No.	Quantity	Connection	Procedure
99	$B'r$	Deck tilt component solver to dials	Set $B'gr$ at 45°, and Dd at 0°. Position vector gear with slot toward rear. Movement of L cam should cause no movement of vertical ($L \cos 2B'r$) rack. Motion of rack may be measured with a dial indicator.
28	L	Deck tilt component solver to L dials	Position cam so that rotation of vector gear through 360° causes no motion of output racks. Adjust L dials to read 2000 min. Motion of vertical rack may be measured with a dial indicator.
58	L	Dials to L-16	Adjust so that stop acts at 480 and 3520 min. on L dials.
242	$B'gr$ or $B'r$	Drive to parallax component solver	In instruments for BB's, CA's, CB's, CVB's, and CL's, push double slide gear down into mesh with bevel gear on 14-A22 ($B'r$ line) and tighten in place. In instruments for CV's, and all one-director ships, push double slide gear up into mesh with bevel gear on 14-A11 ($B'gr$ line) and tighten in place.
243	$B'gr$ or $B'r$	Parallax component solver to dials	Set Dd and $B'gr$ at 0°. Position vector gear with slot toward front. Movement of $1/R2$ cam should cause no movement of vertical rack.
49	(sin $B'gr$ or $B'r$)/$R2$	Ph computer to parallax component solver	Set Dd and $B'gr$ at 0°. Position input rack so that movement of sec ($E2+L$) cam causes no movement of Ph output rack. Motion of output may be measured on Ph dials.
517	Ph	Dial to synchro	Hold synchro on electrical zero. Adjust Ph dial to read zero.
52	Ph	Transmitter to computer	Set Dd and $B'gr$ at 0°. Adjust so that Ph dial reads zero.
156	$R2$	$1/R2$ cam to $R2$ counters	Set Dd at 0°, $B'gr$ at 90°, and $R2$ at 1560 yards. Turn sec ($E2+L$) cam of Ph computer until cam follower is at outer constant radius, and hold cam. Position $1/R2$ cam of parallax component solver so that Ph dial reads RIGHT 10°59′.

Adj. No.	Quantity	Connection	Procedure
3	$E2+L$	*Ph* computer to $E2+L$	Set *Dd* at 0°, *B′gr* at 90°, *L* at 2000 min., *E2* at 60°, and *R2* at 1560 yards. Position sec $(E2+L)$ cam of *Ph* computer so that *Ph* dial reads RIGHT 7°20′.
226	(cos *B′gr* or *B′r*)/*R2*	*Pv* computer to parallax component solver	Set *Dd* at 0°, and *B′gr* at 90°. Position input rack so that movement of sin $(E2+L)$ cam causes no movement of *Pv* output rack. Motion of output may be measured on *Pv* dial.
227	$E2+L$	*Pv* computer to $E2+L$	Set *E2* at 0°, and *L* at 2000 min. Position sin $(E2+L)$ cam of *Pv* computer so that movement of input rack causes no movement of *Pv* output rack. To move input rack, set *Dd* and *B′gr* at 0°, and move *R2*. Motion of output rack may be measured on *Pv* dial.
548	*Pv*	Dial to synchro	Hold synchro on electrical zero. Adjust *Pv* dial to read zero.
228	*Pv*	Transmitter to computer	Set *Dd* and *E2* at 0°, *B′gr* at 90°, and *L* at 2000 min. Adjust so that *Pv* dial reads zero.
504	Sync *E*	Coarse to fine dial	Adjust dials to agree at index.
503	DIP	Coarse to fine dial	Adjust dials to agree so that infinity sign on fine dial and counterclockwise edge of white block on coarse dial are together at index.
90	Sync *E*	Sync *E* dials to *Eb* stop (L-11) and *E* dials	Set *E* at −5°, and *L* at 800 min. Position *Eb* stop at lower limit (toward left). Adjust sync *E* dials to match fixed index. Set *E* at 85° and *L* at 3500 min. Turn *Eb* to upper limit and check that sync *E* dials are again matched at fixed index.
91	DIP	DIP dials to *E*, *L*, and sync *E* dials	Set *E* at 0°, *L* at 2000 min. and match sync *E* dials at index. Adjust DIP dials to read infinity.

Adj. No.	Quantity	Connection	Procedure
12		Brakes to sync *E* handcrank	Adjust brakes so that when the sync *E* handcrank is in the IN position the brake on the sync *E* line is applied, and when it is in the CENTER or OUT positions, the brake on the *E* line is applied. A brake is applied when its cam is clear of its roller. Proceed as follows: Put the sync *E* handcrank in the OUT position. Turn the cam shaft until the round side of the *E* brake cam (rear cam) is toward the bottom and the flat is about 1/8 inch clear of the brake arm roller. Tighten A-12 and put the handcrank in the CENTER position. The *E* brake cam should be positioned so that the round part is toward the top and the other flat is clear of the roller by about 1/8 inch or by an amount equal to that previously established for the OUT position.
259	*E*	Counter in corrector unit to *E* dials	Adjust counter to agree with *E* dials.
60	$Eb+Vs$	Intermittent drive to Vs counter	Set L at 2000 min., E at 80°, and match sync E dials at index. Adjust so that upper cut-out point of intermittent drive occurs at 2360 min. on Vs counter. Check that with E at 0°, lower cut-out point occurs at 1640 min. on Vs counter.
35	Zd	Dz computer to Zd dials	Set Zd at 2000 min. Position vector gear with slot horizontal. Movement of $f(Eb+Vs)$ cam should cause no movement of output rack. Motion of rack may be measured on Dd follow-up.
216	Dz	Spring to Dz line	Set Zd at 2000 min. and wind spring 3 turns.

Adj. No.	Quantity	Connection	Procedure
112	*Zd*	$(Zd)^2$ cam to *Zd* dials	Set *Zd* at 2000 min. For approximate adjustment, position $(Zd)^2$ cam so that $(Zd)^2$ rack is at extreme front position. To refine the adjustment, make sure that A-113 is loose and that there is no output from $Zd \cdot Ds$ multiplier when *Zd* line is moved. Rotate tan $(Eb + Vs)$ cam until cam follower is on inner constant radius. Synchronize *Vz* follow-up temporarily, at zero on *Vz* dials, by means of A-63. Move *Zd* to 1400 min. and note reading of *Vz* dials. Move *Zd* to 2600 min. and again read *Vz*. The two readings should be equal. If they are not, refine A-112. Repeat the check with *Zd* at 800 min. and 3200 min., and further refine A-112 if necessary.
208	*Ds*	$Zd \cdot Ds$ multiplier to *Ds* counter	Set *Ds* at 500 mils. Position *Ds* input rack so that movement of *Zd* rack causes no movement of output rack. Motion of output may be measured on *Vz* follow-up.
113	*Zd*	$Zd \cdot Ds$ multiplier to *Zd* dials	Set *Zd* at 2000 min. Position *Zd* input rack so that movement of *Ds* rack causes no movement of output rack. Motion of output may be measured on *Vz* follow-up.
63	*Vz*	*Vz* dials to multipliers	Set *Zd* at 2000 min., and *Ds* at 500 mils. Position tan $(Eb + Vs)$ cam with follower on outer constant radius. Synchronize *Vz* follow-up so that *Vz* dials read zero.
36	*Ds*	*jDd* computer to *Ds* counter	Set *Ds* at 500 mils. Position input rack so that movement of cos $[E2 + L - K(Zd)^2]$ cam produces no movement of vector gear output. Motion of output may be measured on *Dd* follow-up.
215	*jDd*	Spring to *jDd* line	Set *Ds* at 500 mils, and wind spring 3½ turns.
33	*jDd*	*Dd* dials to *Dz* and *jDd* computers	Set *Ds* at 500 mils and *Zd* at 2000 min. Position $f(Eb + Vs)$ cam follower on inner radius and cos $[E2 + L - K(Zd)^2]$ cam follower on outer radius. Synchronize *Dd* follow-up so that *Dd* dials read zero.

Adj. No.	Quantity	Connection	Procedure
236	*Dd*	Holding friction	Adjust friction to prevent *B'r* from backing out *Dd*, but not so tight as to overload *Dd* servo motor. Usual adjustment is to tighten spring fully, but not solidly, leaving minimum space between coils.
34	$E2+L-K(Zd)^2$	*jDd* computer to $E2+L-K(Zd)^2$	Set *L* and *Zd* at 2000 min., *E2* at 60° and *Ds* at 700 mils. Keep *Dd* follow-up energized. Position cos $[E2+L-K(Zd)^2]$ cam so that *Dd* dials read 23°35′. Tighten A-34 and set *Ds* at 300 mils. *Dd* should then read –23°35′. If it does not, refine by adjusting both the plus and the minus reading until errors are of equal magnitude and like sign.
61	$Eb+Vs$	*Dz* computer to $Eb+Vs$	Set *Ds* at 500 mils, *Vs* and *L* at 2000 min., *E* at 60°, sync *E* dials at index, and *Zd* at 3200 min. Keep *Dd* follow-up energized. Position $f(Eb+Vs)$ cam so that *Dd* dials read 30°34′. Tighten A-61 and set *Zd* at 800 min. *Dd* should then read –30°34′. If it does not, balance plus and minus readings as for A-34.
32	$Eb+Vs$	$(Zd)^2$ tan $(Eb+Vs)$ multiplier to $(Eb+Vs)$	Set *Ds* at 500 mils, *Vs* and *L* at 2000 min., *E* at 60°, sync *E* dials at index, and *Zd* at 3200 min. Keep *Vz* follow-up energized. Position tan $(Eb+Vs)$ cam so that *Vz* dials read 316 min. Set *Zd* at 800 min. and check that *Vz* dials again read 316 min.
		Before making further adjustments, run the unit check test of the trunnion tilt computer, page 222. Refine adjustments as necessary.	
111	*Zd*	$Zd\ (L-L\cos 2B'r)$ multiplier to *Zd* dials	Set *Zd* at 2000 min. Position input screw so that movement of input rack causes no movement of output rack. Motion of output may be measured on *jB'r* follow-up.
64	$L\cos 2B'r$	$Zd\ (L-L\cos 2B'r)$ multiplier to $L\cos 2B'r$	Set *L* at 2000 min. Position input rack so that movement of input screw causes no movement of output rack. Motion of output may be measured on *jB'r* follow-up.

Adj. No.	Quantity	Connection	Procedure
65	L	$L(L \sin 2B'r)$ multiplier to L dials	Set L at 2000 min. Position input screw so that movement of input rack causes no movement of output rack. Motion of output may be measured on $jB'r$ follow-up.
57	$L \sin 2B'r$	$L(L \sin 2B'r$ multiplier to $L \sin 2B'r$	Set $B'gr$ and Dd at 0°. Position input rack so that movement of input screw causes no movement of output rack. To measure motion of output rack, set Zd at 2000 min. and observe motion on $jB'r$ follow-up.
199	Br	Br dials to L-18	Set $B'gr$ and Dd at 0°. Adjust so that $jB'r$ stop acts at 348°20′ (−11°40′) and +11°40′ on Br dials.
62	$L(L \sin 2B'r)$	Br dials to deck tilt corrector	Set L and Zd at 2000 min., $B'gr$ and Dd at 0°. Synchronize $jB'r$ follow-up so that Br dials read 0°.

Run test of deck tilt computer. The necessary test sheets are contained in the log book, NAVORD Form 1229. If the test errors are excessive, make the unit check test of the deck tilt computer, page 220, to locate incorrectly positioned elements. Refine the adjustments as necessary.

92	$R2$	Indicating counter to $R2$ line	Adjust $R2$ indicating counter to agree with $R2$ counters in ballistic computers.
513	$E'g$	Dial to coarse synchro (automatic transmitter)	Hold synchro on electrical zero. Adjust dial to read 20.
514	$E'g$	Dial to fine synchro (automatic transmitter)	Hold synchro on electrical zero. Adjust dial to read 00.
4	$E'g$	Coarse to fine synchro (automatic transmitter)	Adjust so that coarse and fine synchros are on electrical zero together. (Dials to agree.)
515	$E'g$	Dial to coarse synchro (indicating transmitter)	Hold synchro on electrical zero. Adjust dial to read 20.
516	$E'g$	Dial to fine synchro (indicating transmitter)	Hold synchro on electrical zero. Adjust dial to read 00.

Adj. No.	Quantity	Connection	Procedure
6	$E'g$	Coarse to fine synchro (indicating transmitter)	Adjust so that coarse and fine synchros are on electrical zero together. (Dials to agree.)
5	$E'g$	Indicating to automatic transmitter	Adjust so that transmitter dials agree.
51	$Vs-Vz$	$E'g$ transmitters to $Vs-Vz$ line	Set Vs and L at 2000 min., Vz at 0 min., and DIP at infinity. Adjust so that $E'g$ transmitter dials read 2000 min.
10	$B'r$	Coarse to fine synchro ($B'r$ receiver)	Transmit electrical zero to fine and coarse synchros. Slip-tighten A-10. Turn servo motor by hand until coarse center contact is aligned with center interrupter contact. Hold worm to maintain this alignment and turn servo further until fine center contact is midway between outer contacts. Tighten A-10.
98	$B'r$	Dials to $B'r$ receiver	Transmit electrical zero to $B'r$ receiver synchros, and energize receiver. Set Dd at 0°. Adjust so that $B'gr$ dials read 0°.
70	$cB'r$	Bearing dials to $B'r$ local control	Energize $B'r$ receiver at electrical zero. Set L and Zd at 2000 min. Turn control switch to AUTO. After cBr dial is at rest, turn control switch to SEMI-AUTO. Turn jBr to set nearest graduation on cBr dial to 0° on Br. Turn control switch to LOCAL. Adjust A-70 so that Br dials read 0°.
1	Eb	Coarse to fine synchro (Eb receiver)	Transmit electrical zero to fine and coarse synchros. Slip-tighten A-1. Turn servo motor by hand until coarse center contact is aligned with center interrupter contact. Hold worm to maintain this alignment and turn servo further until fine center contact is midway between outer contacts. Tighten A-1.
50	Eb	$E'g$ dials to Eb receiver	Transmit electrical zero to Eb receiver synchros, and energize receiver. Set Vz at 0 min., and Vs at 2000 min. Adjust so that $E'g$ dials read 2000 min.

Adj. No.	Quantity	Connection	Procedure
2	*Co*	Coarse to fine synchro (*Co* receiver)	Transmit electrical zero to fine and coarse synchros. Slip-tighten A-2. Turn servo motor by hand until coarse center contact is aligned with center interrupter contact. Hold worm to maintain this alignment and turn servo further until fine center contact is midway between outer contacts. Tighten A-2.
179	*Co*	Dials to *Co* receiver	Transmit electrical zero to *Co* receiver synchros, and energize receiver. Set *Br* at 0°. Adjust so that *B* dial reads zero.

STAR SHELL COMPUTER MK 1 MOD 0

Adj. No.	Quantity	Connection	Procedure
50	*Fn*	Dial to coarse synchro (*Fn* transmitter)	Hold coarse synchro on electrical zero. Adjust dial to read 10 sec.
51	*Fn*	Dial to fine synchro (*Fn* transmitter)	Hold fine synchro on electrical zero. Adjust dial to read 0.0 sec.
13	*Fn*	Coarse to fine synchro (*Fn* transmitter)	Adjust so that coarse and fine synchro are on electrical zero together.
52	*E′gn*	Dial to coarse synchro (*E′gn* transmitter)	Hold coarse synchro on electrical zero. Adjust dial to read 20.
53	*E′gn*	Dial to fine synchro (*E′gn* transmitter)	Hold fine synchro on electrical zero. Adjust dial to read 00.
14	*E′gn*	Coarse to fine synchro (*E′gn* transmitter)	Adjust so that coarse and fine synchros are on electrical zero together.
54	*B′grn*	Dial to coarse synchro (*B′grn* transmitter)	Hold coarse synchro on electrical zero. Adjust dial to read 0.
55	*B′grn*	Dial to fine synchro (*B′grn* transmitter)	Hold fine synchro on electrical zero. Adjust dial to read 0.

Adj. No.	Quantity	Connection	Procedure
15	*B′grn*	Coarse to fine synchro (*B′grn* transmitter)	Adjust so that coarse and fine synchro are on electrical zero together.
56	*Rjn*	Dial to synchro (*Rjn* receiver)	Set *Rjn* ring dial at zero. Hold synchro on electrical zero. Adjust inner dial so that pointer matches zero index of ring dial.
2	*Rjn*	Ring dial to L-2	Adjust so that stop acts at IN 1500 yards and OUT 1500 yards on ring dial.
3	*Rjn*	Coarse detent to *Rjn* dial	Set *Rjn* ring dial at zero. Position each detent in notch.
4	*Rjn*	Fine detent to *Rjn* dial	
–	*WrD* + *KRdBs*	Drum to counter	Adjust counter drum to agree with counter.
6	*WrD* + *KRdBs*	Counter to L-1	Adjust so that stop acts at +60 knots (060) and –60 knots (940) on counter.
16	*Fn*	Transmitter dials to L-3	Adjust so that stop acts at 8.20 and 41.55 sec. on *Fn* dials.
8	*Fn*	Holding friction	Adjust friction to hold *Fn* setting.
57	*Fn*	Fuze range dial to *Fn* dials	For powder fuze, set *Fn* dials at 10.60 sec. Adjust powder fuze range dial to read 5000 yards. For mechanical fuze, set *Fn* dials at 14.50 sec. Adjust mechanical fuze range dial to read 7600 yards.
5	*jDwn*	Ring dial to L-4	Adjust so that stop acts at 4000 and 15,000 yards on range ring dial.
7	*jDwn*	Holding friction	Adjust friction to hold *jDwn* setting.
1	*R2n*	Assembly clamp	Tighten clamp.
10	*Rjn*	Elevation multiplier to *Rjn* ring dial	For initial adjustment, set *Rjn* at IN 200 yards. Position multiplier input rack 2½ inches from rear end of rack guide rail, and tighten A-10. Check the adjustment as follows: Wedge *E′g* input shaft (41-S15) and *jDwn* in-

Adj. No.	Quantity	Connection	Procedure
10 (Continued)			put gear. Temporarily tighten A-9. Set *Rjn* at OUT 1000 yards. Check that increasing *Fn* 20 secs. causes an increase of 309.6 min. on *E′gn* dials. If necessary, refine A-10 until the change in *E′gn* is correct.
9	*Fn*	Elevation multiplier to *Fn* dials	For initial adjustment, set *Fn* at 20.85 sec. Position multiplier slide block 2½ inches from end of its guide rail. (Measure from input end to nearest edge of slide block.) Tighten A-9. Check the adjustment as follows: Wedge *E′g* input shaft (41-S15) and *jDwn* input gear. Set *Fn* at 35 sec. Check that changing *Rjn* from IN 1400 to OUT 1400 yards causes an increase of 393.4 min. on *E′gn* dials. If necessary, refine A-9 until the change in *E′gn* is correct.
12	*WrD* + *KRdBs*	Deflection multiplier to counter	Set *WrD* + *KRdBs* at 0 knots. Position input rack so that rotation of input screw causes no movement of output rack. To measure output motion, wedge *B′gr* input shaft (41-S13), tighten A-17 temporarily, and observe motion on *B′grn* dials.
11	*jDwn*	Deflection multiplier to range ring dial	For initial adjustment, set range ring dial at 8000 yards. Position multiplier slide block 2½ inches from end of its guide rail. (Measure from input end to nearest edge of slide block.) Tighten A-11. Check the adjustment as follows: Wedge *B′gr* input shaft (41-S13). Tighten A-17 temporarily. Set range ring dial at 5000 yards. Check that increasing *WrD* + *KRdBs* from 0 to 50 knots causes an increase of 9°41′ on *B′grn* dials. If necessary, refine A-11 until the change in *B′grn* is correct.
—	Range spot	Friction relief drives on knobs	Adjust each friction to drive line normally without slipping, but to slip without straining the line when the limit stop is reached.
—	Range		

Adjusting Star Shell Computer Mk 1 Mod 0 to Computer Mk 1

Adj. No.	Quantity	Connection	Procedure
18	$R2n$	$R2n$ counter to $R2$ counter	Set Rjn at 0 yards. Adjust so that $R2n$ reading is equal to $R2$ reading plus 1000 yards.
17	$Dtown$	$B'grn$ dials to $B'gr$ dials	Set $WrD + KRdBs$ at 0 knots. Adjust so that $B'grn$ reading is equal to $B'gr$ reading.
230	$WrD + KRdBs$	Counter in star shell computer to counter in computer unit	Synchronize $WrD + KRdBs$ follow-up so that counters agree.
231	$E'g$	$E'gn$ dials to $E'g$ dials	Set fuze range dial and range ring dial at 8000 yards, and Rjn at 0 yards. Adjust so that: For powder fuze, $E'gn$ reading equals $E'g$ reading plus 383 min. For mechanical fuze, $E'gn$ reading equals $E'g$ reading plus 373 min.

STAR SHELL COMPUTER MK I MOD 1

Adj. No.	Quantity	Connection	Procedure
50	Fn	Dial to coarse synchro (Fn transmitter)	Hold each synchro on electrical zero. Adjust each dial so that its index mark is at fixed index.
51	Fn	Dial to fine synchro (Fn transmitter)	
13	Fn	Coarse to fine synchro (Fn transmitter)	Adjust so that coarse and fine synchros are on electrical zero together.
52	$E'gjn$	Dial to coarse synchro ($E'gjn$ transmitter)	Hold each synchro on electrical zero. Adjust each dial so that its index mark is at fixed index.
53	$E'gjn$	Dial to fine synchro ($E'gjn$ transmitter)	

Adj. No.	Quantity	Connection	Procedure
14	*E'gjn*	Coarse to fine synchro (*E'gjn* transmitter)	Adjust so that coarse and fine synchros are on electrical zero together.
54	*B'grjn*	Dial to coarse synchro (B'*grjn* transmitter)	Hold each synchro on electrical zero. Adjust each dial so that its index mark is at fixed index.
55	*B'grjn*	Dial to fine synchro (*B'grjn* transmitter)	
15	*B'grjn*	Coarse to fine synchro (*B'grjn* transmitter)	Adjust so that coarse and fine synchros are on electrical zero together.
56	*Rjn*	Dial to synchro (*Rjn* receiver)	Set *Rjn* ring dial at zero. Hold synchro on electrical zero. Adjust inner dial so that pointer matches zero index of ring dial.
2	*Rjn*	Ring dial to L-2	Adjust so that stop acts at OUT 1500 yards and IN 2857 yards (red dot beyond IN 1500 calibration).
4	*Rjn*	Detent to ring dial	Set *Rjn* ring dial at zero. Position detent in notch.
—	*WrD* + *KRdBs*	Drum to counter	Adjust counter drum to agree with counter.
6	*WrD* + *KRdBs*	Counter to L-1	Adjust so that stop acts at +60 knots (060) and −60 knots (940) on counter.
26	*Fn*	Assembly clamp	Tighten clamp.
19	*Fn*	Counter to L-3	Adjust so that stop acts at 8.20 and 41.55 sec. on *Fn* counter.
8	*Fn*	Holding friction	Adjust friction to hold *Fn* setting.
57	*Fn*	Fuze range dial to *Fn* counter	For powder fuze, set *Fn* counter at 10.60 sec. Adjust powder fuze range dial to read 5000 yards. For mechanical fuze, set *Fn* counter at 14.50 sec. Adjust mechanical fuze range dial to read 7600 yards.
5	*jDwn*	Ring dial to L-4	Adjust so that stop acts at 4000 and 15,000 yards on range ring dial.

Adj. No.	Quantity	Connection	Procedure
7	*jDwn*	Holding friction	Adjust friction to hold *jDwn* setting.
1	*R2n*	Assembly clamp	Tighten clamp.
58	*E′gjn*	Fine to coarse dial	Set ring dial at 20. Adjust inner dial to read 00.
22	*E′gjn*	Assembly clamp	Tighten clamp.
59	*E′jn*	Coarse to fine dial	Set ring dial at zero. Adjust inner dial so that center graduation is at index.
60	*B′jn*	Coarse to fine dial	Set ring dial at zero. Adjust inner dial so that center graduation is at index.
61	*B′grjn*	Fine to coarse dial	Set ring dial at zero. Adjust inner dial to read zero.
23	*B′grjn*	Assembly clamp	Tighten clamp.
10	*Rjn*	Elevation multiplier to *Rjn* ring dial	For initial adjustment, set *Rjn* at IN 200 yards. Position multiplier input rack 2½ inches from rear end of rack guide rail, and tighten A-10. Check the adjustment as follows: Wedge *E′g* input shaft (41-S15), *E′jn* input gear, and *jDwn* input gear. Temporarily tighten A-9. Set *Rjn* at OUT 1000 yards. Check that increasing *Fn* 20 sec. causes an increase of 309.6 min. on *E′gjn* dials. If necessary, refine A-10 until the change in *E′gjn* is correct.
9	*Fn*	Elevation multiplier to *Fn* counter	For initial adjustment, set *Fn* at 20.85 sec. Position multiplier slide block 2½ inches from end of its guide rail (measure from input end to nearest edge of slide block). Tighten A-9. Check the adjustment as follows: Wedge *E′g* input shaft (41-S15), *E′jn* input gear, and *jDwn* input gear. Set *Fn* at 35 sec. Check that changing *Rjn* from IN 1400 to OUT 1400 yards causes an increase of 393.4 min. on *E′gjn* dials. If necessary, refine A-9 until the change in *E′gjn* is correct.

Adj. No.	Quantity	Connection	Procedure
12	$WrD + KRdBs$	Deflection multiplier to counter	Set $WrD + KRdBs$ at 0 knots. Position input rack so that rotation of input screw causes no movement of output rack. To measure output motion, wedge $B'gr$ input shaft (41-S13) and $B'jn$ input gear, tighten A-17 temporarily, and observe motion on $B'grjn$ dials.
11	$jDwn$	Deflection multiplier to range ring dial	For initial adjustment, set range ring dial at 8000 yards. Position multiplier slide block 2½ inches from end of its guide rail. (Measure from input end to nearest edge of slide block.) Check the adjustment as follows: Wedge $B'gr$ input shaft (41-S13), and $B'jn$ input gear. Tighten A-17 temporarily. Set range ring dial at 5000 yards. Check that increasing $WrD + KRdBs$ from 0 to 50 knots causes an increase of 9°41′ on $B'grjn$ dials. If necessary, refine A-11 until the change in $B'grjn$ is correct.
16	Fn	Transmitter to counter	Set Fn at 10 sec. Adjust so that index marks on transmitter dials are at indexes.
24	$E'gjn$	Transmitter to dials	Set $E'gjn$ at 2000 min. Adjust so that index marks on transmitter dials are at indexes.
25	$B'grjn$	Transmitter to dials	Set $B'grjn$ at 0°00′. Adjust so that index marks on transmitter dials are at indexes.
—	Range spot	Friction relief drives on knobs and hand-cranks	Adjust each friction to drive line normally without slipping, but to slip without straining the line when the limit is reached.
—	Range		
—	Deflection		
—	Elevation		
—	Deflection	Holding friction in hand-crank	Adjust each friction to hold setting for both positions of handcrank.
—	Elevation		

Adjusting Star Shell Computer Mk 1 Mod 1 to Computer Mk 1

Adj. No.	Quantity	Connection	Procedure
18	$R2n$	$R2n$ counter to $R2$ counter	Set Rjn at 0 yards. Adjust so that $R2n$ reading is equal to $R2$ reading plus 1000 yards.
17	$Dtown$	$B'grjn$ dials to $B'gr$ dials	Set $WrD + KRdBs$ at 0 knots, and $B'jn$ at 0 mils. Adjust so that $B'grjn$ reading is equal to $B'gr$ reading.
230	$WrD + KRdBs$	Counter in star shell computer to counter in computer unit	Synchronize $WrD + KRdBs$ follow-up so that counters agree.
231	$E'g$	$E'gjn$ dials to $E'g$ dials	Set fuze range dial and range ring dial at 8000 yards, Rjn at 0 yards, and $E'jn$ at 0 mils. Adjust so that: For powder fuze, $E'gjn$ reading equals $E'g$ reading plus 383 min. For mechanical fuze, $E'gjn$ reading equals $E'g$ reading plus 373 min.

Part nine

SKETCH LISTS

Introduction

Whenever a part of the computer has been disassembled for repair or overhaul, it is always advisable to have at hand the drawings of the affected units. For the repair of some units, especially when new parts are to be installed, reference to the drawings is essential in order to meet established tolerances and to secure proper alignment of the unit.

This section contains lists of assembly drawing numbers for all of the units in the Computer Mark 1, Mods 0 to 16, and the Star Shell Computer Mark 1, Mods 0 to 2. When a particular drawing is required for reference, its number may be obtained from the list if the unit name and the modification and serial numbers of the computer have been ascertained. A complete list of drawings for all parts of the instrument would be so lengthy as to require a volume in itself. Therefore, only the assembly drawing numbers are listed. The drawing numbers of all *parts* are listed on the assembly drawings themselves. For some of the more complex units, several assembly drawings are required. In order to keep the sketch lists brief, only the "key" drawing number is listed for each of these units. On a "key" drawing, the complete list of assembly drawings pertaining to a unit may be found.

This section also serves as an index to certain drawings of a general nature which are frequently required for maintenance purposes. These drawings include the schematic, the wiring, and the gearing diagrams for the Computer Mark 1 and the Star Shell Computer Mark 1.

GENERAL

	MOD 0	MOD 1 & 9	MOD 2	MOD 3 & 10
SCHEMATIC DIAGRAM	209301	209901 209311	209951 SER. NO. 99 AND LOWER 210540 SER. NO. 101 AND HIGHER	210394 SER. NO. 99 AND LOWER 210541 (MOD 10)
WIRING DIAGRAM	209302	209902	209952 SER. NO. 99 AND LOWER 209953 SER. NO. 101 AND HIGHER	210254

DESTROYER LEADERS, DD356 TYPE
CV'S
LIGHT DESTROYERS, DD409 AND DD453 TYPE
BB'S, CA'S, CL'S, AND CB'S
2100-TON DESTROYERS, DD445 TYPE, AND AUXILIARIES
SPARES
2200-TON DESTROYERS, DD692 TYPE

RING DIAGRAMS

	MOD 0	MOD 1 & 9	MOD 2	MOD 3 & 10
OL AND COMPUTER UNITS	209303	209903	209903 SER. NO. 99 AND LOWER 210464 SER. NO. 101 AND HIGHER	210098 (SER. NO. 100) 210465 SER. NO. 101 AND HIGHER
INDICATOR AND CORRECTOR UNITS	209304	209904	209914	210100

Gene Slover's US Navy Pages | Table of Contents

MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 11	MOD 13	MOD 14 & 16	MOD 15
210395 SER NO. 99 AND LOWER 210542 SER. NO. 101 AND HIGHER	210397 SER. NO. 99 AND LOWER 210543 SER. NO. 101 AND HIGHER	210398 SER. NO. 215 AND LOWER 210608 SER. NO. 216 TO 389 INC. 210850 SER. NO. 390 TO 518 INC. 210709 SER. NO. 519 AND HIGHER	210730 210731	210710	210711 SER. NO. 780 AND LOWER 2001 TO 2050 210805 SER. NO. 781 TO 810 INC. 222941 SER. NO. 811 AND HIGHER	222921	222918
210256	210262 SER. NO. 99 AND LOWER 210258 SER. NO. 101 AND HIGHER		210732			222894	222928
		210677 210260 210582 210583 210584 210628 210630		210260 210628	210677 210260 210582 210583 210584 210628 210630		
210392 SER. NO. 99 AND LOWER 210466 SER. NO. 101 AND HIGHER	210099 SER. NO. 99 AND LOWER 210467 SER. NO. 101 AND HIGHER	210467 SER. NO. 215 AND LOWER 210466 SER. NO. 216 TO 389 INC. 210851 SER. NO. 390 TO 518 INC. 210694 SER. NO. 519 AND HIGHER	210735	210695	210096 SER. NO. 780 AND LOWER 2001 TO 2050 210086 SER. NO. 781 TO 810 INC. 222942 SER. NO. 811 AND HIGHER	222919	222916
210101	210103	210104 SER. NO. 215 AND LOWER 210607 SER. NO. 216 AND HIGHER	210736	210607	210607	222920	222917

GENERAL (CONTINUED)

CASE AND COVERS

	MOD 0	MOD 1 & 9	MOD 2	MOD 3 & 10
ALL UNITS	209650	210919	210072 SER. NO. 99 AND LOWER 210074 SER. NO. 101 AND HIGHER	210073
CONTROL AND COMPUTER UNITS				
INDICATOR AND CORRECTOR UNITS				

HANDCRANKS

	MOD 0	MOD 1 & 9	MOD 2	MOD 3 & 10
HANDCRANKS	REFER TO B.M.55503	209458 TO 209464 INC. 209646-5 209765-3 209871-4	195062-9 210353-1 210478-1 195066-5	210353 TO 210356-1

CONTROL UNIT

	MOD 0	MOD 1 & 9	MOD 2	MOD 3 & 10
RANGE RATE INTEGRATOR	209354	209354	210268	210268
RANGE INTEGRATOR	209355	209355	194077-1	194077-1
SHIP COMPONENT SOLVER	209358	209358	210269	210269
TARGET COMPONENT AND HEIGHT SOLVERS	209360	209360	210271	210271
dH AND dRh COMPONENT SOLVERS	209364	209364	210274	210274
VECTOR SOLVER	209366	209366	210276	210276
1/50 HP A-C MOTOR	207920-1	207920-1	207920-1	207920-1
1/20 HP A-C MOTOR, TIME	146191	146191	146191	146191
4-MFD. CAPACITOR	207920-2	207920-2	207920-2	207920-2
2-MFD. CAPACITOR	207924-1	207924-1	207924-1	207924-1
6-MFD. CAPACITOR	NONE	NONE	NONE	NONE
FOLLOW-UPS, dRh, RdE, dR	209329	209329	209329	209329
FOLLOW-UPS, jE, jBr	209330-1	209330-1	210295	210295
FOLLOW-UPS, Sh, Ct	209698-1	209698-1	210316	210316
FOLLOW-UP, RdBs	209933	209333	210331	210331

MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 11	MOD 13	MOD 14 & 16	MOD 15
210448 SER. NO. 99 AND LOWER 210073 SER. NO. 101 AND HIGHER	210071 SER. NO. 99 AND LOWER 210073 SER. NO. 101 AND HIGHER	210073 SER. NO. 360 AND LOWER			210616 SER. NOS. UP TO 750 INC.		
		210616 SER. NO. 361 TO 581 INC.	210714 210616	210616	210714	210714 210616	210714 222932
		210617 SER. NO. 361 TO 581 INC.	210617 222927	210617 210645	210617 210645	210617 222927	210617 222988
195062-9 210353-1 210356-1 210478-1	210353-1 210354-1 210355-2 210356-1	195062-9 195066-5 210353-1 210354-1 210355-1	195062-9 195066-5 210353-1 210354-1 210355-1	195062-9 195066-5 210353-1 210354-1 210355-1	195062-9 195066-5 210353-1 210354-1 210355-2	195062-9 195066-5 210353-1 210354-1 210355-2	195062-9 195066-5 210353-1 210354-1 210355-2

MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
210268 194077-1	210268 194077-1	210268 194077-1	210268 194077-1	210268 194077-1	210268 194077-1	210268 194077-1
210269 210271 210274 210276	210269 210271 210274 210276	210269 210271 210274 210276	210269 210271 210274 210276	210269 210271 210274 210276	210269 210271 210274 210276	210269 210271 210274 210276
207927 146191	207927 146191	207927 146191	207927 146191	207927 146191	207927 146191	207927 146191
207920-2 207924-1 207925-3	207920-2 207924-1 207925-3	207920-2 207924-1 207925-3	207920-2 207924-1 NONE	207920-2 207924-1 NONE	207920-2 207924-1 NONE	207920-2 207924-1 NONE
209329 210295 210316 210331	209329 210295 210316 210331	209329 210295 210316 210331	209329 210295 210316 210331	209329 210295 210316 210331	209329 210295 210316 210331	209329 210295 210316 210331

CONTROL UNIT (CONTINUED)

	MOD 0	MOD 1 & 9	MOD 2
RANGE RECEIVER	209336	209336	209336
RADAR RANGE RECEIVER	NONE	NONE	210438
ΔcB'r AND ΔcEb INDICATING TRANSMITTERS	NONE	209930	209930
TIME MOTOR REGULATOR	207004	207004	207004
BATTLE AND SHELL ORDER ANNUNCIATOR	209350	209350	209350
RANGE FINDER'S, POINTER'S, AND TRAINER'S SIGNAL SOLENOIDS	209351-1	209351-1	209892-1
SOLENOID CLUTCH	209352-1	209352-1	210289-1
SOLENOID LOCK	209348-1	209348-1	210290-1
REMOTE CONTROL RELAYS	NONE	NONE	NONE
TWO-UNIT COMPONENT INTEGRATORS	209353	209353	210291
FRAME 66 DAMPER	207916-1	207916-1	207926
MAGNETIC DRAG	NONE	NONE	195049-1
SYNCHRO MOTOR 5F MK 4 MOD 3 (RANGE RECEIVER)	173005	173005	173005
SYNCHRO GENERATOR 1F MK 8 MOD 3 (RADAR RANGE REC.)	NONE	NONE	173150
SYNCHRO GENERATOR 5G MK 1 MOD 3	173105	173105	173105
INDICATOR GENERATOR—RANGE AND BEARING SOLUTION	NONE	NONE	173170
SWITCHES	55527	55527	195051 210335-1
TOP PLATE OF CONTROL UNIT	209825	209856	210472
CONTROL UNIT GEARING	209800	209800	209800

COMPUTER UNIT

	MOD 0	MOD 1 & 9	MOD 2
INTEGRATORS, RdE, RdBs, 1/cR, Sec E	209355	209355	194077
ELEVATION WIND COMPONENT SOLVER	209359	209359	210270
HORIZ. WIND COMPONENT SOLVER	209368	209368	210278
Vf+Pe BALL. COMPUTER	209314	209314	209399
1/cR COMPUTER	209318	209318	210279
Sec E COMPUTER	209319	209319	210280

MOD 3 & 10	MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
210314	210314	210314	210314	210692	210692	210692	210692
210438	210438	210438	210438	NONE	NONE	NONE	NONE
209930	209930	209930	209930	209930	209930	209930	209930
195022	195022	195022	195022	195022	195022	195022	195022
NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
209892-1	209892-1	209892-1	209892-1	209892-1	209892-1	209892-1	209892-1
210289-1	209289-1	209289-1	209289-1	209289-1	209289-1	209289-1	209289-1
210290-1	210290-1	210290-1	210290-1	210290-1	210290-1	210290-1	210290-1
NONE	210220	210220	210220	210220	210220	210220	210220
210291	210291	210291	210291	210291	210291	210291	210291
207926	207926	207926	207926	207926	207926	207926	207926
195049-1	195049-1	195049-1	195049-1	195049-1	195049-1	195049-1	195049-1
173005	173005	173005	173005	173005	173005	173005	173005
173150	173150	173150	173150	NONE	NONE	NONE	NONE
173105	173105	173105	173105	173105	173105	173105	173105
173170	173170	173170	173170	NONE	NONE	NONE	NONE
195051	195051	195051	195051	195051	195051	195051	195051
210335-1	210335-1	210335-1	210335-1	210335-1	210335-1	210335-1	210335-1
210473	210474	210474	210474	210474	210474	210474	210474
210476	210477	210477	210477 SER. NO. 518 AND LOWER 210719 SER. NO. 519 TO 780	210720	210720	210720	210720

MOD 3 & 10	MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
194077	194077	194077	194077	194077	194077	194077	194077
210270	210270	210270	210270	210270	210270	210270	210270
210278	210278	210278	210278	210278	210278	210278	210278
210437	210437	210437	210437	210750 (MOD 8) 210759 (MOD 12)	210437	287534 (MOD 14) 287535 (MOD 16)	287486
210413	210413	210413	210413	210413	210413	210413	210413
210280	210280	210280	210280	210280	210280	210280	210280

COMPUTER UNIT (CONTINUED)

	MOD 0	MOD 1 & 9	MOD 2
RANGE RATE CORRECTOR AND GEARING	209666	209666	210281
Tf BALL. COMPUTER	209315-1	209315-1	210328-1
Fp BALL. COMPUTER	209315-2	209315-2	210328-2
Tf/R2 BALL. COMPUTER	209315-4	209315-4	210328-4
Fm BALL. COMPUTER	209315-3	209315-3	210328-3
PREDICTION MULTIPLIERS	209316	209316	210375
COMPLEMENTARY ERROR CORRECTOR	209326	209326	210085
FOLLOW-UPS, V, Ywgr, R2, Vf+Pe, Tf/R2, F, WrD+KRdBs	209329	209329	210329
FOLLOW-UP, Dtwj	209933	209933	210331
FOLLOW-UP, Tf	209062	209062	195029
INTERMITTENT DRIVES, E, E2, cR, dRs	194017	209069	210320
Co RECEIVER	209337	209337	210454
INTEGRATOR GEARING	209691	209911	210145
PREDICTION MULTIPLIER INPUT GEARING	209669	209669	210105
WIND COMPONENT SOLVERS—OUTPUT GEARING	209671	209671	210300
HORIZ. WIND COMPONENT SOLVER OUTPUT GEARING	209673	209921	210299
I.V., AND Tg DIAL ASSEMBLY	209674	209674	210302

MOD 3 & 10	MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
210430	210430	210430	210430	210776	210430 SER. NO. 780 AND LOWER 210811 SER. NO. 781 AND HIGHER	210573	287465
209665-1 209665-2 209665-4	209665-1 209665-2 209665-4	209665-1 209665-2 209665-4	209665-1 209665-2 209665-4	210751-1 NONE 210751-2	209665-1 NONE 209665-4 SER. NO. 810 AND LOWER 222899 SER. NO. 811 AND HIGHER	287540 NONE 287547	287489 NONE 287496
209665-3	209665-3	209665-3	209665-3	210755	209665-3 SER. NO. 780 AND LOWER 222874 SER. NO. 781 AND HIGHER	287550	287497
209893	209893	209893	209893	210779	209893 SER. NO. 780 AND LOWER 210813 SER. NO. 781 AND HIGHER	287575	287500
210090 210329 210331 195029 210320 210532 210155	210090 210329 210331 195029 210320 210532 210158	210090 210329 210331 195029 210320 210532 210158	210090 210329 210331 195029 210320 210532 210158 SER. NO. 215 AND LOWER 210602 SER. NO. 216 TO 518 INC. 210718 SER. NO. 519 AND HIGHER	210090 210329 210331 195029 210320 210532 210718	210090 210329 210331 195029 210320 210532 210718	210090 210329 210331 195029 210320 210532 210718	210090 210329 210331 195029 210320 210532 210718
210106	210107	210107	210107	210781	210107 SER. NO. 780 AND LOWER 210815 SER. NO. 781 AND HIGHER	287567	287474
210300	210300	210300	210300	210768	210300 SER. NO. 780 AND LOWER 222861 SER. NO. 781 AND HIGHER	287579	287477
210299 210302	210299 210302	210299 210302	210299 210302	210299 210772	210299 210302 SER. NO. 780 AND LOWER 210809 SER. NO. 781 AND HIGHER	210299 287577	210299 287577

COMPUTER UNIT (CONTINUED)

	MOD 0	MOD 1 & 9	MOD 2
PREDICTION MULTIPLIER OUTPUT GEARING	209676	209676	210303
PREDICTION FOLLOW-UP MOUNTING	209679	209679	210308
WIND COMPONENT SOLVERS—INPUT GEARING	209682	209682	210311
BALL. COMPUTER MOUNTING AND GEARING	209383	209383	210066
PREDICTION MULTIPLIER MOUNTING AND GEARING	209822	209931	210110
CHANGE OF BEARING FILTER	NONE	NONE	210436
Co RECEIVER (COARSE) SYNCHRO MOTOR 5B MK 5 MOD 3	172905	172905	172905
Co RECEIVER (FINE) SYNCHRO MOTOR 5F MK 4 MOD 3	173005	173005	173005
ELEVATION SOLUTION TRANSMITTER	NONE	NONE	NONE
ΔcB'r (AUTO) AND ΔcEb (AUTO) TRANSMITTER	185004	185004	185004
1/50 HP A-C MOTOR	207927	207927	207927
4-MFD. CAPACITOR	207920–2	207920–2	207920–2
2-MFD. CAPACITOR	207924–1	207924–1	207924–1
6-MFD. CAPACITOR	NONE	NONE	NONE
FRAME 66 DAMPER	207926	207926	207926
SIZE 11 MAGNETIC DAMPER	207929	207929	207929
MAGNETIC DRAG	195049–1, 3	195049–1, 3	195049–1, 3
SWITCHES	210335–1	210335–1	210335–1

MOD 3 & 10	MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
210434	210434	210435	210434	210785	210434 SER. NO. 780 AND LOWER 222863 SER. NO. 781 AND HIGHER	287583	287470
210308	210308	210308	210308	210789	210308 SER. NO. 780 AND LOWER 222865 SER. NO. 781 AND HIGHER	287571	210789
210311 210066	210311 210066	210311 210066	210311 210066	210792 210794	210311 210066 SER. NO. 780 AND LOWER 222867 SER. NO. 781 TO 810 INC. 222935 SER. NO. 811 AND HIGHER	287581 287564	210311 287504
210110	210111	210111	210111	210801	210111 SER. NO. 780 AND LOWER 222871 SER. NO. 781 AND HIGHER	287587	287506
210436	210436	210436	210436	210436	210436	210436	210436
172905	172905	172905	172905	172905	172905	172905	172905
173005	173005	173005	173005	173005	173005	173005	173005
NONE	173170	173170	173170	NONE	NONE	NONE	NONE
185004	185004	185004	185004	185004	185004	185004	185004
207927	207927	207927	207927	207927	207927	207927	207927
207920-2	207920-2	207920-2	207920-2	207920-2	207920-2	207920-2	207920-2
207924-1	207924-1	207924-1	207924-1	207924-1	207924-1	207924-1	207924-1
NONE	207925-3	207925-3	207925-3 SER. NO. 518 AND LOWER	NONE	NONE	NONE	NONE
207926	207926	207926	207926	207926	207926	207926	207926
207929	207929	207929	207929	207929	207929	207929	207929
195049-1, 3	195049-1, 3	195049-1, 3	195049-1, 3	195049-1, 3	195049-1, 3	195049-1, 3	195049-1, 3
210335-1	210335-1	210335-1	210335-1	210335-1	210335-1	210335-1	210335-1

INDICATOR UNIT

	MOD 0	MOD 1 & 9	MOD 2
1/50 HP A-C MOTOR	207920-1	207920-1	207927
4-MFD. CAPACITOR	207920-2	207920-2	207920-2
SINGLE-SPEED SYNCHRO RECEIVERS, S_o, R_j, D_j, V_j	209333-1	209333-1	210371
F AND D_s TRANSMITTERS	209342	209844	209342
V_s TRANSMITTER	209347	209843	210352
INTERMITTENT DRIVES, D_s AND V_s	194017	209069	210320
SYNCHRO MOTOR 5B MK 3 MOD 3, S_o, R_j, D_j, V_j	45005	172905	172905
SYNCHRO GENERATOR 6G MK 2 MOD 3, V_s, D_s, F	46604	185004	185004
SYNCHRO GENERATOR 7G MK 3 MOD 3	47604	173204	173204
MAGNETIC DRAG	NONE	NONE	195049-2
SWITCHES	55527	209431-9	195051
INDICATOR UNIT—DIALS AND GEARING	209686	209920	209920

CORRECTOR UNIT

	MOD 0	MOD 1 & 9	MOD 2
D_z AND $_jD_d$ COMPUTERS	209362	209362	210272
DECK TILT COMPONENT SOLVER	209363	209363	210273
PARALLAX COMPONENT SOLVER	209367	209367	210277
DECK TILT MULTIPLIERS	209322	209322	209912
$Z_d \cdot D_s$ MULTIPLIER	209323	209323	210332
Z_d^2 TAN (E_b+V_s) MULTIPLIER	209325	209325	210293
PARALLAX MULTIPLIER (TRAIN)	209327	209327	210286
PARALLAX MULTIPLIER (ELEVATION)	NONE	NONE	NONE
FOLLOW-UPS, D_d, $_jB'_r$, V_z	209332	209332	210287
FOLLOW-UP (B'_r LOCAL CONTROL)	209357	209357	210330
COMPENSATORS, V_z, D_d, E_b, B'_r, $_jB'_r$	NONE	NONE	209926
B'_r RECEIVER	209334	209334	210120
E_b RECEIVER	209335	209335	210115
B'_{gr} TRANSMITTERS (AUTO. AND IND.)	209338	209338	209998
E'_g (AUTO. AND IND.) AND PARALLAX TRANSMITTERS	209340	209340	210034
INTERMITTENT DRIVE (E_b+V_s)	194017	209069	210320
1/50 HP A-C MOTOR	207920-1	207920-1	207927
4-MFD. CAPACITOR	207920-2	207920-2	207920-2
16-MFD. CAPACITOR	207925-1	207925-1	207925-1

MOD 3 & 10	MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
207927	207927	207927	207927	207927	207927	207927	207927
207920-2	207920-2	207920-2	207920-2	207920-2	207920-2	207920-2	207920-2
210371	210371	210371	210371	210371	210371	210371	210371
210359	210360	210125	210570	210760	210570	210760	287451
210352	210181	210119	210550	210762	210550	210762	287450
210320	210320	210320	210320	210320	210320	210320	210320
172905	172905	172905	172905	172905	172905	172905	172905
185004	185004	185004	185004	185004	185004	185004	185004
173204	173204	173204	173204	173204	173204	173204	173204
195049-2	195049-2	195049-2	195049-2	195049-2	195049-2	195049-2	195049-2
195051	195051	195051	195051	195051	195051	195051	195051
210363	210364	210130	210575 SER. NO. 215 AND LOWER 210600 SER. NO. 216 AND HIGHER	210763	210600	210763	287456

MOD 3 & 10	MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
210272	210272	210272	210272	210272	210272	210272	210272
210273	210273	210273	210273	210273	210273	210273	210273
210277	210277	210277	209975	209975	209975	209975	222961
209912	209912	209912	209912	209912	209912	209912	209912
210332	210332	210332	210332	210332	210332	210332	210332
210293	210293	210293	210293	210293	210293	210293	210293
210286	210286	210286	209977	209977	209977	209977	222963
NONE	NONE	NONE	209978	209978	209978	209978	222962
210287	210287	210287	210287	210287	210287	210287	210287
210330	210330	210330	210330	210330	210330	210330	210330
209926	209926	209926	209926	209926	209926	209926	209926
210120	210120	210120	210120	210120	210120	210120	210120
210115	210115	210115	210115	210115	210115	210115	210115
210431	210432	210433	210593	210593	210593	222967	287453
210039	210044	210044	210049	210742	210049	210742	222974
210320	210320	210320	210320	210320	210320	210320	210320
207927	207927	207927	207927	207927	207927	207927	207927
207920-2	207920-2	207920-2	207920-2	207920-2	207920-2	207920-2	207920-2
207925-1	207925-1	207925-1	207925-1	207925-1	207925-1	207925-1	207925-1

CORRECTOR UNIT (CONTINUED)

	MOD 0	MOD 1 & 9	MOD 2
FRAME 66 DAMPER	207916–1	207916–1	207926
FRAME 50 DAMPER	207914–1	207914–1	210321
SWITCHES	55527	209431–9	195051
SYNCHRO MOTOR 5B MK 5 MOD 3	45605	172905	172905
SYNCHRO MOTOR 5F MK 4 MOD 3	45405	173005	173005
SYNCHRO GENERATOR 7G MK 3 MOD 3	47604	173204	173204
PARALLAX CORRECTOR	209349	209349	210370
jDd AND Dz COMPUTER MOUNTING	209377	209377	210028
Zd • Ds AND Zd^2 TAN (Eb+Vs) MOUNTING	209384	209384	210338
DECK TILT COMPUTER MOUNTING	209386	209386	210342
DECK AND TRUNNION TILT CORRECTOR MOUNTING	209369	209905	210004
CORRECTOR FOLLOW-UP GEARING	209373	209374	210056

MOD 3 & 10	MOD 4	MOD 6	MOD 7	MOD 8 & 12	MOD 13	MOD 14 & 16	MOD 15
207926	207926	207926	207926	207926	207926	207926	207926
210321	210321	210321	210321	210321	210321	210321	210321
195051	195051	195051	195051	195051	195051	195051	195051
172905	172905	172905	172905	172905	172905	172905	172905
173005	173005	173005	173005	173005	173005	173005	173005
173204	173204	173204	173204	173204	173204	173204	173204
210370	210370	210370	209981	222880	209981	222879	222964
210028	210031	210031	210031	210031	210031	210031	210028
210338	210338	210338	210338	210338	210338	210338	210338
210342	210342	210342	210342	210737	210342	210737	210737
210006	210006	210006	210568	210568	210568	210568	210568
209990	210439	209991	209992 SER. NO. 215 AND LOWER	210610	210610	210610	210610
			210610 SER. NO. 216 AND HIGHER				

STAR SHELL COMPUTER

	MOD 0	MOD 1	MOD 2
GEARING DIAGRAM	191715	222143	193702
SCHEMATIC DIAGRAM	191702	222142	193701
WIRING DIAGRAM	191703	191794	193717
ASSEMBLIES			
COMPLETE ASSEMBLY	191701	222145	193704
	191710	222146	193705
	191711	222147	193706
	191712		
DIALS AND GEARING	191707	222152	193710
	191709	222185	222154
MULTIPLIER	191708	191708	193707
TRANSMITTER MOUNTING	191713	222149	193708
	191714	222150	193709
SYNCHRO MOTOR 1F MK 8 MOD 3	173150		
SYNCHRO GENERATOR 6G MK 2 MOD 3	185004	185004	185004
SYNCHRO DIFF. GEN. 6DG MK 5 MOD 3	185105	185105	185105
SYNCHRO CAPACITOR TYPE 9C MK 3 MOD 3	210511	210511	210511
HANDCRANKS		222148-2	222148-2
		222165-1	222165-1
MULTIPLIER GEARING	191704	191705	195705
	191705	222157	193715
	191706	222158	193716
SYNCHRO MOTOR 1F MK 8 MOD 3A		173130	173130

DISTRIBUTION

Requests for additional copies of OP 1064A should be submitted on NavGen 47, Stock Forms and Publications Requisition, through the District Publications and Printing Office by which addressee is serviced. Mailing addresses may be obtained from list 10.VV of the Standard Navy Distribution.

Standard Navy Distribution List No. 48 (Part 1) and Edition No. 5 (Part 2) to Catalog of Activities of the Navy
2 copies unless otherwise indicated.

1.A,B,C,D,E,G,H,I,K,L,M; 2.C,D,E,F,G,I,S; 3.(5 copies), B,M; 3.H*,U,V,X,Z,TT,VV,ZZ,LLL,OOO,WWW,EEEE,FFFF; 6.A; 7.(6 copies),D; 7.(18 copies),V; 7.(5 copies),K,M,N,P; 7.FFF,HHH; 8.K*,S,CC; 8.(5 copies),T 35,T60; 10.(25 copies),VV - 500 to West Coast; 11.(CNO,ComdtMarCorps, BuOrd*); 12. BuOrd Special List 12.A; 13.(5 copies),N.

*Applicable Addressees